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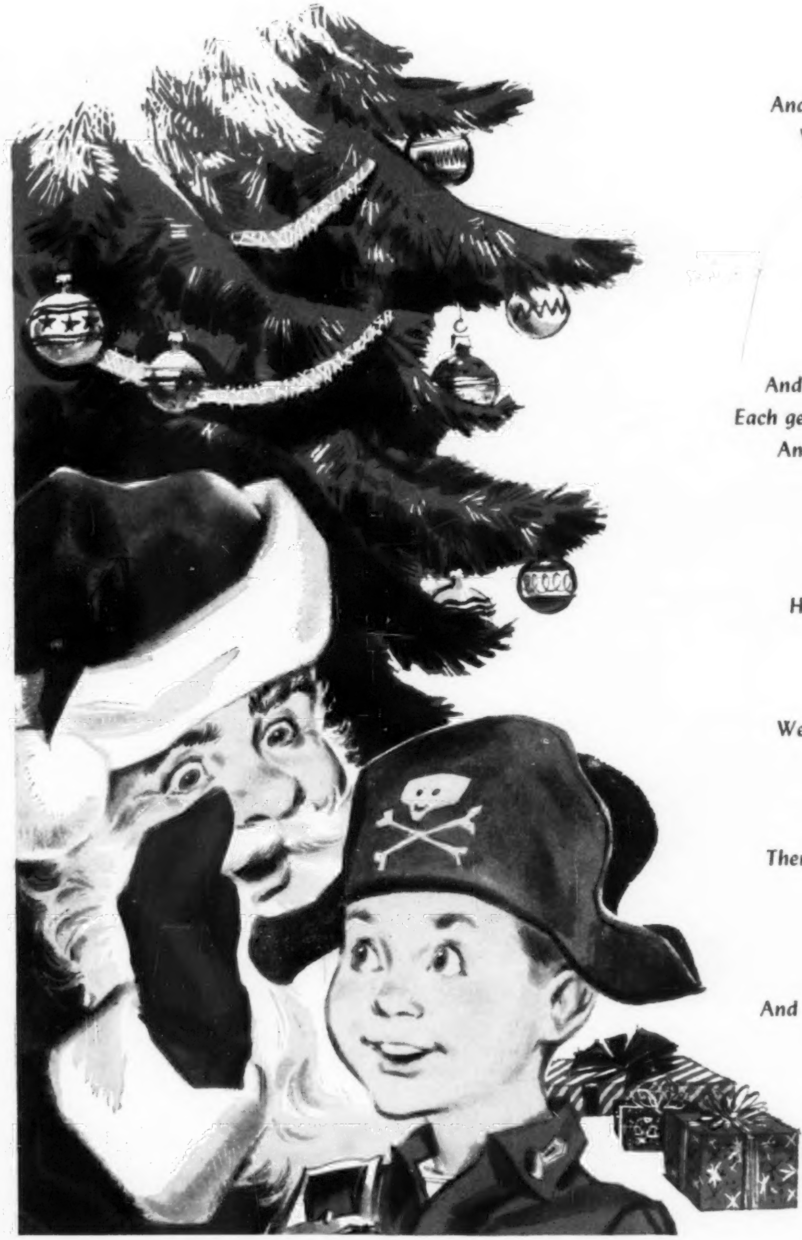

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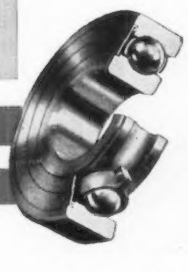

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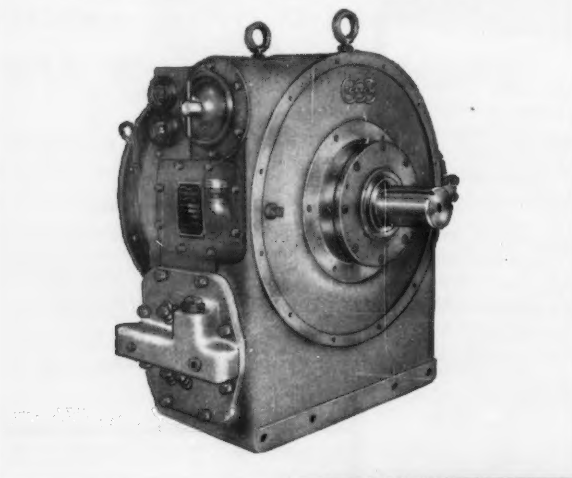

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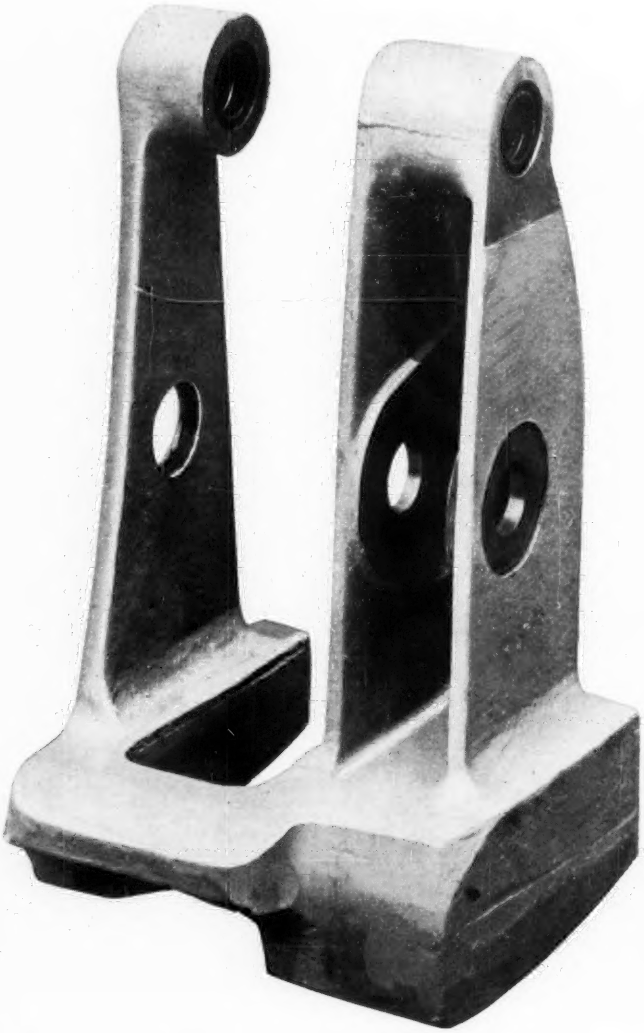

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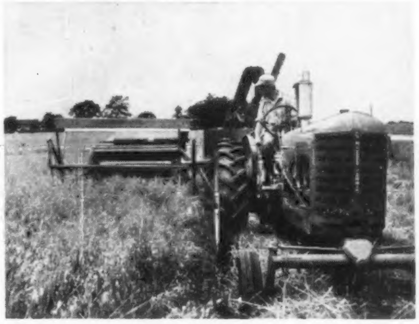

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Truck bodies "show" Missouri farmers

USS MAN-TEN STEEL construction is best!

Mr. James B. Cunningham of La Grange anticipates long life from his Knapheide MAN-TEN STEEL body.

Mr. J. H. Wheeler of Canton, Missouri, stands beside his 1954 truck with its Knapheide body of USS MAN-TEN HIGH STRENGTH STEEL.

MR. JAMES B. CUNNINGHAM, farmer of La Grange, Missouri, has this to say about his Knapheide farm truck body. "I have purchased 16 Knapheide beds over 17 years. I find that they are very durable, lighter than other steel beds. They won't kink after hauling heavy machinery and they will last 18 months longer than other steel beds. On a Knapheide bed the steel sides stay flat when loading a large amount of grain on the truck. Knapheide all-steel sides resist warping with heavy usage."

ANOTHER MISSOURI FARMER, MR. J. H. WHEELER of Canton, is very satisfied with his USS Man-Ten High Strength Steel Knapheide truck body. "This body is all Man-Ten Steel, except the floor, and I feel that I can use this truck body much longer than one built of carbon steel. Another consideration is the High Strength Steel side racks. They are lighter and easier to handle than they would be built of heavier gage carbon steel. Also, these trucks often have to stay out in the weather, and USS Man-Ten Steel affords good resistance to atmospheric corrosion."

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AGRICULTURAL ENGINEERING

VOL. 37 DECEMBER, 1956 No. 12

Agricultural V-Belt Development

Dale L. Waugh

TODAY'S research and development engineer has at his command a large and ever increasing variety of materials and methods. It is his job to assemble these into a finished product that will perform in such a manner as to solve a specific V-belt drive problem. In so doing, he breaks the over-all V-belt design problem down into a number of components, trying and eliminating until the finished sample is produced.

This is done by setting up norms for laboratory and field testing based on experience factors and on customers' estimated service requirements. This establishes the development goal. Then follows the individual valuation of the compounds, fabrics and cords to be used in the first test samples.

After the individual evaluation of materials is completed, certain groups of materials are assembled in experimental belts which are tested on V-belt testers to determine the properties of the composite assembly. V-belt testers are specially designed machines capable of testing one or more of a belt's properties.

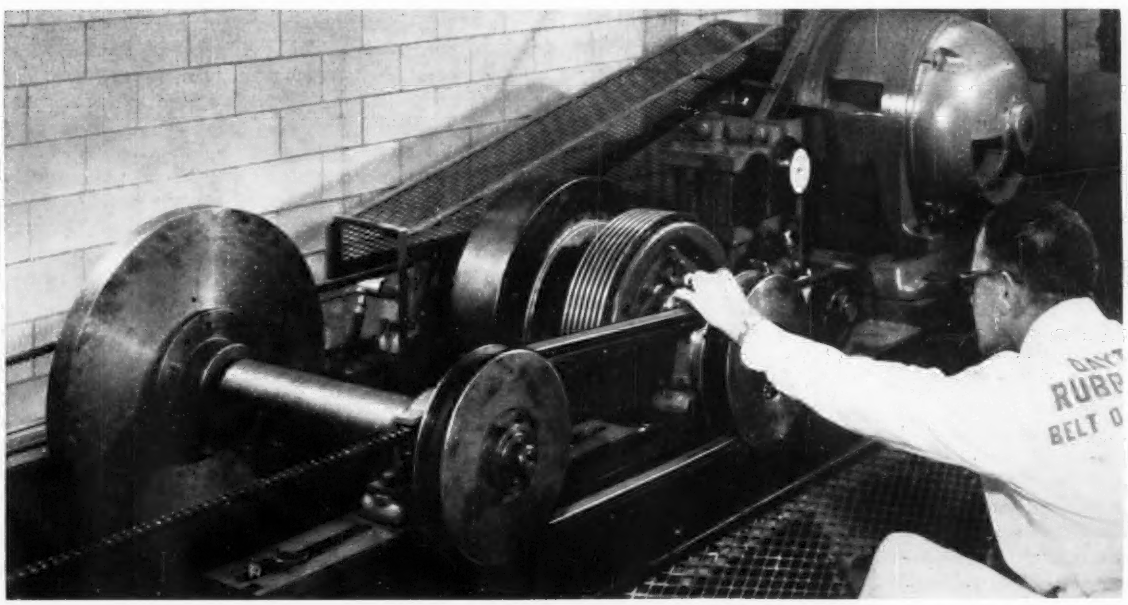
Paper presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1955, on a program arranged by the Power and Machinery Division.

The author—DALE L. WAUGH—is director of V-belt research and development, The Dayton Rubber Co., Dayton, Ohio.

The vast and ever increasing variety of materials and methods available for agricultural V-belt development presents one of the most interesting challenges ever faced by research and development engineers

For example, we have V-belt tests in our laboratories for determining tensile strength; for determining a belt's tendency to fray under a variety of conditions; for determining the squeak or noise-generating characteristics of a belt; for determining the conductivity and static generating properties; for determining performance at very low temperatures, and also at very high temperatures. We have tests that determine the slip and stretch characteristics of a belt; tests for determining the flexibility and life of a belt, both under load and without load; tests to determine the frequency and amplitude of vibrations generated by the belt; and tests that we perform on customers' units in our own laboratory.

Although laboratory tests are important it is felt that it is imperative for field tests to be run on all developments before they can be considered a solution to the particular problem. Field testing introduces factors such as weather, faulty maintenance and foreign materials that cannot be incorporated into laboratory tests. Experience has taught that a



Laboratory V-belt testers are not a complete substitute for field testing, but are designed to determine such characteristics as tensile strength, slippage, stretch, flexibility, squeak, tendency to fray, frequency and amplitude of vibration, and other factors important to belt life

development which looks satisfactory on a laboratory test will often be less successful on a field test.

In order to be assured of getting reliable test data from field tests with respect to any new development, two considerations are suggested: *(a)* that the largest possible number of tests be put in the field and, *(b)*, that it be an authorized test conducted through and by the original equipment manufacturer, rather than have it field tested by a farmer. Having our own agricultural service engineers in the field has made it possible for us to get progressive test results reported promptly to our laboratory. It then becomes necessary for the development engineer to correlate field tests with laboratory tests, by recording the percent of the norms achieved, in order that he may be able to properly evaluate his development. Unless this is done, full benefit of field tests cannot be gained and development cannot be called complete.

Some of the materials that go into an agricultural V-belt are as follows:

carbon black	sodium acetate
buna rubber	resorcinol
neoprene rubber	formaldehyde
natural rubber	caustic soda
whiting	santomerse
zinc oxide	latex rubber
sulphur	vinyl pyridine latex
stearic acid	cotton
rubber processing oil	cotton fibers
rosin	Super cordura
rosin oil	Dacron
vulcanizing agents	Nylon
anti-oxidants	Nylon blends
plasticizers	Rayon
softeners	textile spirits
graphite	aromatic solvent
magnesium oxide	

Each of these materials performs a definite function within the compound or belt structure. Any slight variation in their percentage in the mix or position in the belt will affect the performance of the finished product. Rather than discuss these materials individually, they can be collected into three groups; namely, compounds, fabrics and cords.

The so-called "compound materials" are purchased as raw or basic materials. They are formed into the basic stocks by development engineers who specialize in compounding. Mixing is done on a mill employing two large steel rolls turning at different speeds, mixing the rubber with a kneading action. These compounds are designed exclusively for use in V-belts and are not used in any other product manufactured by our company.

The fabric materials are fabrics woven from raw cotton or synthetic yarns by a mill of our choice, from a specification written by our development engineers. The raw yarn is purchased from a yarn producer and sent to the textile mill for fabrication. When the mill has completed the weaving of the yarn into fabric, it is then sent to our plant for processing. There it is rubberized according to the job it is going to be required to do. Fabric is rubberized by a process called calendering. This consists of working thin layers of rubber into, or onto, the fabric material. The development engineer is constantly working on the calendering specifications in order to improve the rubberized fabric he uses in constructing the V-belt he is developing. An atomic eye, energized by radioactive Strontium 90, is used to improve quality control in producing rubberized and calendered fabric. Thickness, weight and uniformity are recorded on a graph, giving precise results.

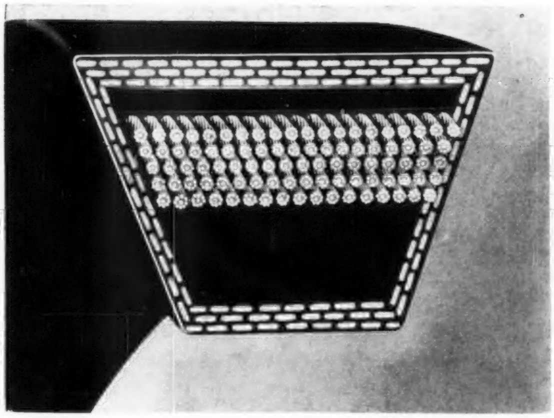
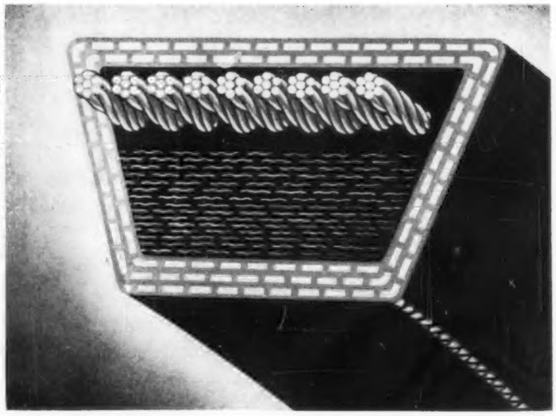
The strength member, or neutral axis, of an agricultural V-belt is made up of the natural or synthetic fibers and consists of either a single ply of cord or a number of plies of cord. The cord used to make this strength member is obtained by much the same processs used to obtain fabric. That is, the raw yarn is bought from the manufacturer and shipped to a mill of our choice, where, according to the specifications written by our development engineers, it is twisted into a plied or cabled cord. This twisted cord is then sent to our plant where it receives a special treatment in that it is normalized, impregnated, dehydrated and set according to the specifications established by our development department. This work is done on a special Walter Kidde cord processing machine which is used by all major V-belt manufacturers. The cord, having been so treated, is now ready to be built into a V-belt.

The making of a modern agricultural V-belt has become a science in itself, and it is the development engineer's responsibility not only to develop better agricultural V-belts, but also to improve and work out new processes by which these belts are fabricated. The development of processes and machines are just as important as the development of the product design itself. There is an orderly process that must be adhered to in order that the belt being built will meet the specifications assigned to it.

V-belts are built on cylindrical steel drums, ply upon ply. The circumference of the drum, of course, fixes the length of the finished belt. In the process of construction, a layer of specially compounded rubber stock—known as the *compression section* of the V-belt—is first applied to the building drum.

Then, one or more layers of high-tensile cords are spun over the compression section. These cords form what we call the *neutral axis*—or strength section—of the V-belt. The amount of moisture which comes in contact with these cords, especially if they are rayon cords, must be rigidly controlled because rayon has a remarkably high affinity for water vapor. After that, one or several layers of rubber-impregnated fabric are applied over the neutral axis section. This fabric layer is known as the *tension section* of the belt. The pressure and tension under under which these several plies are laid on are carefully controlled so as to preserve the desired operating characteristics in the finished V-belt.

Finally, high-speed circular knives cut the V-belt cores from the building drum. The positioning of these knives is micrometer-adjusted so that the exact top width and side angle of the belt can be determined precisely. After the cores have been removed from the building drum they are wrapped with a cover stock especially selected according to the job. Some cover stocks produce a high rate of belt slippage; some have a low rate. Others are especially wear-resistant; still others have great resistance to fatigue resulting from repeated flexing. All cover stocks, regardless of their operating characteristics, are bias-cut, but the angle of the bias is varied to produce different operating properties. Further, the covers can be applied under tension, completely

Natural or synthetic fibers represent the strength member of an agricultural V-belt. These fibers consist of either a number of plies of cord *(left)*, or a single ply *(right)*

relaxed or even crimped to vary the flexing characteristics of the finished belt.

The curing of V-belts is a part of the production process that requires accurate control of pressure and temperature. Short belts generally are cured in multiple cavity circular ring molds of either the solid or collapsible types placed in autoclaves. The longer and heavier belts are cured in multiple-groove flat press plates. Curing is done by the section process using specially designed flat bed hydraulic presses. Curing temperatures range up to 307 F. and curing pressures as high as 400 psi on the belts.

A survey of the major implement manufacturers revealed that 72 percent of the V-belts used were of special design in construction or dimension. In the development of these special belts, the development engineer must first have an accurate understanding of the problem. To know the problem exactly and understand it completely sounds as though it would be quite simple for an experienced engineer. But, too frequently, it is really very difficult. The V-belt in agricultural service is one of the toughest dynamic uses of rubber known. These special V-belts are frequently called upon to operate under one or more widely varying unfavorable drive conditions, such as misalignment, lack of tension adjustment, use as a clutch, absorbing excessive shock, sub-diameter pulleys, back-side idler, space limitations and under-belting. Frequently it is not possible to build into a single V-belt all of the properties required and, consequently, the resultant belt will have a weakness in one direction or another and, in itself, represent a compromise. The equipment builders are themselves in an excellent position to contribute importantly to the elimination of unsatisfactory drive conditions.

Misalignment is of three general types: *(a)* where there is angularity between the pulley centerlines; *(b)* where the pulley centerlines are parallel but a distance apart; *(c)* the reverse direction or figure eight type of drive. A possible solution is to use neutral axis or strength band materials such as nylon, dacron or high-twist rayon because they are extensible. Where the V-belt is to serve as a clutch, it must slip readily when the load is applied or released. This can be accomplished through the use of cover stocks having a low coefficient of friction and a high wear resistance.

Sub-diameter pulleys require extremely flexible belts. Even though drive capacities are reduced, satisfactory belt life can be achieved by a reduction in belt thickness or through the use of cog-type designs. Back-side idlers require the belt to bend in both directions. This is severe service. The idler must never be smaller than the diameter of the smallest pulley of the drive. The solution is to use tension type or stretchy compounds in the compression section and to lower the neutral axis line. Excessive shock and heavy pulsation require neutral axis or strength band constructions that offer changeable ratios between stress and strain without taking a permanent stretch. Some relief under shock can come from softer cross-sections that will work up and down in the pulley groove or wide angle belts that will not wedge so tightly.

Under-belting, often resulting from space limitations or low belt speeds, is a frequent problem on agricultural drives. Higher capacity belts are achieved through utilizing neutral axis cords of greater strength such as the so-called "super" belts or designs offering higher coefficients of friction such as cog-belts. Belts that are asked to perform on fixed center drives having little or no center adjustment must be built of low stretch neutral axis cords. Also, maximum stability of cross-section to keep seating of the belt in the groove to a minimum will help.

There are three types of drives having more than their share of these unfavorable conditions:

> The *cylinder drive* is one requiring a belt of wide capabilities. Up to 40-hp loads are transmitted with slug loads reaching 60 to 70 hp and go so far as to stall out the engine. The belt must have minimum slip and stretch characteristics, be highly squash resistant and capable of operating over sub-diameter pulleys. Proven heavy duty constructions applied to slightly thinner cross sections of arched type appear to answer this problem.
>
> *Double-angle belts* find their widest use in the agricultural field. They have presented an interesting development problem inasmuch as here a drive requires the belt to flex in both directions, run misaligned and twisted and still give high resistance to cover wear. The design of the double-angle belt itself was not so much a development problem as was the development of satisfactory

(Continued on page 820)

The Geometry of Disks and Soil Relationships

W. F. McCreery and M. L. Nichols
Member ASAE Fellow ASAE

This paper reports progress on basic research work directed at securing answers urgently needed to some of the questions of disk design preliminary to efforts in the direction of product development

THE disk is a major tillage implement wherever power farming is practiced. Its use as a primary plowing tool is increasing and it is considered to be the best implement for a wide variety of soil-preparation and fitting jobs. There are at present on the market sturdy reliable disk harrows which are in effective and extensive use in agriculture. The most probable source of significant advancement or improvement is to be expected from the development of a better understanding of soil-implement relationships as a basis for improved methods of use or construction. There are many questions which have been proposed by the implement industry for study with the objective of building functionally better disk harrows and effecting any economies possible by concentrating on certain designs and shapes of disks and eliminating others found unnecessary or overlapping in usage. The questions are directed at developing a sound scientific basis for design and use, and cover problems involving draft, speed, throw, coverage, penetration, packing, and scouring as related to size, concavity, weight, hitches, gang relationships, and other problems of materials and adjustment.

This paper presents a progress report on basic work directed at securing answers to a few of the many questions of design listed as most urgently needed in product improvement. It is confined to an analysis of soil forces on single vertical disks, having various radii of curvature and moving at different angles in the soil. While it does not answer the questions completely, it is offered as a contribution toward understanding the factors involved.

Review of Disk Literature

Although the disk has for many years been one of the more important tillage implements, there is very little in the technical literature covering the relationships of various designs to soil reactions. One of the first reports dealing with the dynamics of the modern harrow was made by McKibben (1)* in 1926. By a general analysis of the soil forces acting on the offset harrow, he showed how, with proper arrangement of gangs, it "was possible to design a disk harrow which tills a strip, the center of which is offset from the center of the tractor and which at the same time operates without side draft upon either the harrow of the tractor." By changes in the hitching, the offset harrow could be made to operate on either side of the tractor and throw the soil to or from the citrus trees it was being used to cultivate. Later Sjogren (2) outlined the evolution of the offset harrow and listed the broad requirements for design of complete implements. More recently, Kramer (3) presented an analysis of the factors involved in the design of an offset disk harrow considering function, operating forces, controls, adjustments, and elements of mechanical construction. Clyde (4) developed field equipment for measuring the reactions of implements to soil forces as a guide for the design of implements, their use, and hitches. Gordon (5) made a study of one-bottom disk plows at the Tillage Machinery Laboratory (USDA) using two firmly packed soils, a silty clay loam and a loamy sand, at a range of moistures considered to be about optimum for tillage. Particular attention was paid to draft, vertical and side forces, and thrust perpendicular to the plane of the disk.

Paper prepared expressly for AGRICULTURAL ENGINEERING.

The authors — W. F. McCREERY and M. L. NICHOLS — are, respectively, assistant agricultural engineer and head, tillage machinery laboratory section (AERB, ARS), U.S. Department of Agriculture.

*Numbers in parentheses refer to the appended references.

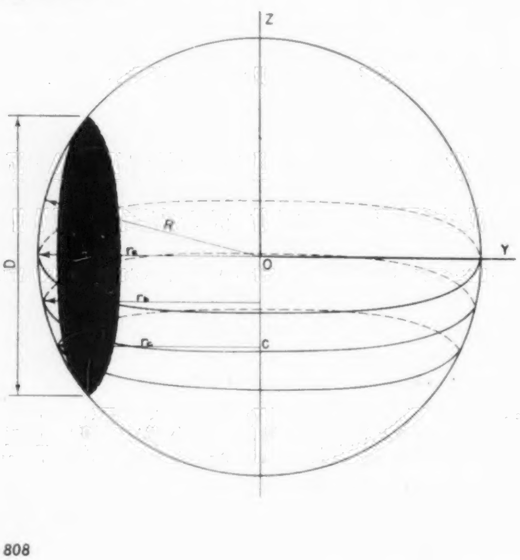


Fig. 1 *(Left)* The disk as a spherical section with parallel horizontal planes intersecting

Fig. 2 *(Right)* Lines showing direction of resultant force at a series of points on a 22-in disk, R=20.24 in, set at 35 deg with line of travel

Geometry of the Common Disk

To understand the relationship of various disk designs to soil reactions, it is necessary to consider certain inherent features of the disk due to its shape. The common disk geometrically is a section of a sphere cut off by a plane P (shaded area, Fig. 1). The radius of the sphere is the radius of curvature R of the disk. The edge of the disk is therefore a circle, and the diameter and depth of concavity of the disk depend on the distance of the plane P from the center O of the sphere and the radius of the sphere. To study the reaction of the soil to the disk, we will assume for simplification that the direction of the pressure of the soil on the disk is in all cases parallel with the line of travel and the reaction is the resultant of the pressure force and the normal to the disk surface at each point where force is applied. (This is, however, an oversimplification since the soil moves across the disk and the actual pressure at any point is the resultant of the force in the line of travel plus the pressure of the soil being forced across the disk surface, which includes the negative effects due to friction and adhesion.) Fig. 2 shows the angles of reaction between the disk surface at various points and the markings of a flexible steel rod applying pressure in the line of travel on a disk having a radius of curvature of 20.24 in.

The vertical force at any point on the disk will be determined from the vertical component of a line that is the intersection of a plane tangent to the disk at that point and a vertical plane through the point parallel with the line of travel. The longitudinal *(L)* and side forces *(S)* at that point will be in a horizontal plane through the point. The horizontal planes, r_a, r_b, r_c, etc. (Fig. 1), cut the sphere, which includes the disk, in perfect circles, the radii of which depend on the distance of each respective plane from O, the center of the sphere. The tangent of the vertical angle of the tangential plane is r_c/O_c. The S force as a component of L may be computed from the general formula $X^2+Y^2+Z^2=R^2$ for the surface of a sphere with its center at the origin O, and the angle ϕ between the line of travel and the plane P, which determines the setting of the disk. Since R and Z are known, or are easily determined, the equation has only two unknowns and can be solved for either in terms of the other. The general equation for changes of Y (or S) with respect to X (or L) in a plane determined by a fixed value of Z may be written $dy/dx=X/(R^2-Z^2-X^2)^{1/2}$. The value of ϕ and the diameter of the disk serve to determine the limits between which the computation is made†.

Practically the summation of soil forces across the disk surface in the longitudinal *(L)*, side *(S)*, and vertical *(V)* directions can be measured quite accurately with suitable testing equipment. Fig. 3 shows the equipment set up for this purpose at the Tillage Machinery Laboratory. The total forces in the three directions are measured and recorded by hydraulic-pressure cells and Bourdon gages. These total values do not explain, however, the nature of the soil-implement reaction which involves packing, throw, pulverization, scouring, and wear. All of these effects are definitely related to shape, size, and angle of travel of the disk, and to physical properties of the soils.

Nature of Soil Reaction to Disks

The disk penetrates the soil and breaks it loose by pressure. In so doing it exerts some cutting and pulverizing

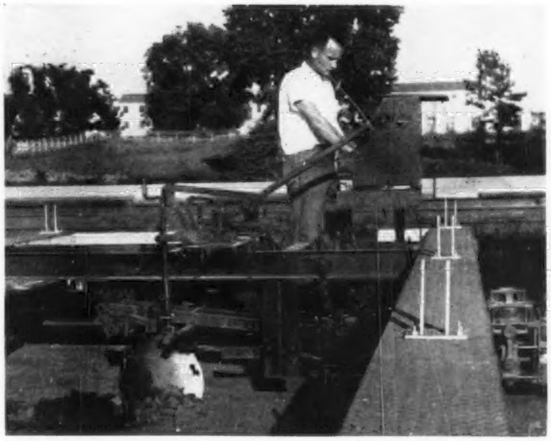


Fig. 3 Test equipment at the USDA Tillage Machinery Laboratory for measuring and recording the L, S, and V components of force on disks

action and inverts or pushes the soil to one side. Weight pushing the disk into the soil is a major element in penetration, and its effectiveness is governed by the angle of the line of pull, the diameter, concavity, thickness, sharpness, and method of sharpening the disk. Frequently penetration of the soil is governed by vegetative matter such as straw residues on cultivated lands, or brush and weeds on new land or pasture, or by rocks and roots on rough lands. While such factors are important to design in that they materially affect requirements of weight and strength, they will not be considered here as part of the soil material proper, since they are often of a temporary nature and of such infinite local variation as to render any precise classification impossible.

Having penetrated the soil, the disk moves forward exterting pressure on it. The direction of pressure depends on the angle of travel and the radius of curvature of the disk. The soil will compress under this forward movement until the pressure equals or exceeds the shear value of the soil. The soil will then break out, the rupture occurring normally in shear planes on about 45 deg with the vertical. Fig. 4 is a diagrammatic sketch of the force reactions causing compaction and shear, showing the nature of the reac-

†A mathematical analysis of the total normal pressure on the concave and convex sides of the disk has been made, but is omitted from this paper as the formulas are complex and are of limited interest to readers of AGRICULTURAL ENGINEERING.

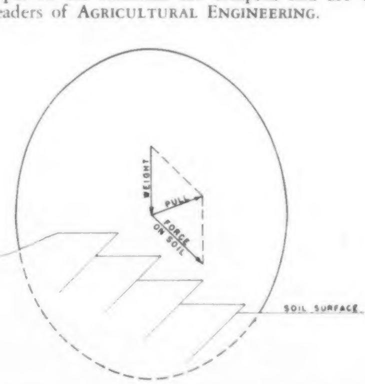


Fig. 4 Diagrammatic sketch of forces (weight, pull, and force on soil) on a disk and shear planes in the soil

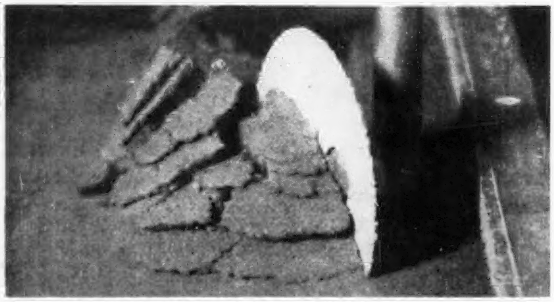


Fig. 5 Model disk ($D=6$ in, $R=7$ in) running 2 in deep in moist Lakeland sand, showing primary and secondary shear planes

tion, and Fig. 5 is a photograph of the shear planes as they form before a model disk in Lakeland sand. The first shear planes to form are called primary shear planes and are caused by a force exerted in the line of travel. These form at quite regular intervals, the distance between the planes being largely determined by physical condition of the soil.

The vertical disk, setting at an angle with the line of travel and having a spherical surface, also exerts a definite pressure to the side. When the disk has no concavity (R=infinity), it exerts no upward or vertical component but the soil is forced by horizontal pressure to slip upward on the shear planes. With the common disk, the concavity also introduces a vertical component of force or an upward pressure. The movement of the soil across the surface of the disk is dependent upon the resultant of pressures exerted on the surface and the resistance to compression or movement by the soil in front of the disk. Angles of the disk and concavity produce an acceleration in movement of the soil to the side so that the soil develops a secondary set of shear planes roughly at right angles to the primary planes. These are also shown in Fig. 5. It is evident from these reactions that the soil properties of resistance to penetration, compression, and shear are of primary importance in the design of disks and their use, as they to a great extent determine the weight required, the draft, strength of frame, size and kind of bearings, curvature of disks, and speeds at which the implement can be used. The abrasiveness of the soil determines the kind of material and the heat-treatments required to reduce wear, and its stickiness governs the smoothness or polish and tangential pressure required for scouring.

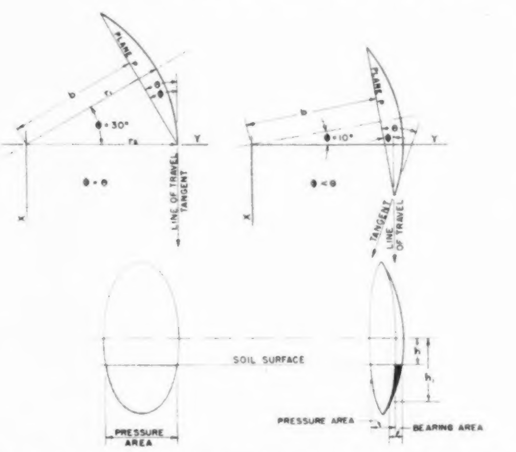


Fig. 6 Diagram of disk showing pressure area and bearing area at two angles, relation of angles of line of travel and tangent line, and dimensions used in mathematical analysis

Packing of Soil by Disks

Disk harrows have been considered by many as tools that cause serious compaction. Since, in general they depend on weight for penetration, this may be expected, but there is little actual data to show the amount of compaction caused by them or how it is produced. Evidence of this compaction was produced by Randolph and Reed (6), where it was shown that the roots of cotton plants did not penetrate appreciably below the tillage depth on plots prepared by the use of disk implements. If the disk is set so that the angle ϕ between the line of travel and the plane P (Fig. 6) is greater than or equal to θ, which is the angle in a horizontal plane at the soil surface between the tangent to the cutting edge and the plane P, there will be no bearing area on the back of the disk. Table 1 shows the angles where $\theta=\phi$ on 8-in model disks running at different depths. If the angle ϕ is less than θ, the back or convex side of the disk will exert pressure on the soil. This usually is a major compressive force. It should be noted from Fig. 6 that, when $\phi=\theta$, the angle between the tangent in a horizontal plane at the edge of the disk and plane P is the same as the angle at the center of the arc in the same horizontal plane between r_1 and r_2, so that the critical value of ϕ can be determined graphically for any depth for any disk of given diameter and radius of curvature.

The bearing on the edge of the disk is materially affected by the method of sharpening the disk. If the disk is sharpened on the back or convex side, the bearing may be increased by an amount depending on the thickness of the disk. If the sharpening is on the concave side, the bearing depends on the setting of the disk. Sharpening on the face side gives the minimum bearing for a disk at any given angle, thus giving greater penetration with a given weight.

In forward motion the bearing on the back or convex side of the disk depends on the radius of curvature (R), the depth of cut, and the angle of travel. When the line of forward travel is parallel with the plane cutting off the disk —a common setting for transport about the farm—half of the convex side below the surface of the soil is bearing on the soil. As the disk is angled for cutting, the bearing on the convex side is the zone between the cutting edge and the locus of the point where the line of travel is tangent to the disk.

To evaluate the packing of soil by a disk, we must account for all or at least the principal forces involved, which are the weight of the disk (including supplemental weights

TABLE 1. ANGLE Θ IN DEGREES AT VARIOUS DEPTHS

Depth of operation (inches)	Radius of Curvature of Disk (inches)				
	5	7	9	11	13
½	33	18½	12½	10½	9
1	41½	25	17	14½	12
1½	46	28½	20	17	14½
2	49	31	22	18½	15
2½	51	33	23	20	16½
3	52	34	24	20½	17
3½	53	34½	24½	21	17½
4	53½	35	25	21½	18

Angle Θ between the plane P and the horizontal tangent to the disk edge at the soil surface for 8-in disks having various radii of curvature at given depths of operation. Angles are shown to the nearest ½ deg.

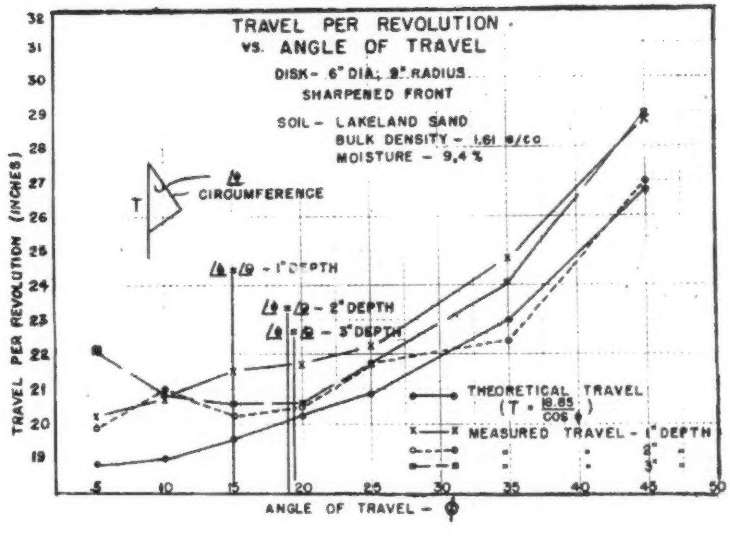


Fig. 7 *(Right)* Travel per revolution versus angle of travel, with disk sharpened on front to reduce bearing area

if such are added) and the pull of the tractor. Correcting experimental values for friction and adhesion of soil to the implement, the resultant of the weight and pull equals the soil reaction. Such information is needed not only to enable the designer or operator to appraise the packing effects but to evaluate the effectiveness of different designs in terms of the degree of achievement of the objectives of disking. The total packing force of the disk in forward motion, including the pressure on the convex side as pointed out above, then apparently is the vector sum of the pull and the weight and can be calculated in terms of L, S, and V. This simple calculation is far from giving the complete picture of the soil-disk reaction causing compaction, since the soil reacts with a series of pressure build-ups and the partial collapse of these pressures when the soil breaks along shear planes. The pressures on the soil are vectored or arched out through a considerable volume of soil and any or all of the weight may be carried on the back or convex side of the disk. Fig. 6 shows the pressure area on the face and the bearing area on the back of a disk set at angles of 30 and 10 deg with the line of travel. Table 2 shows these areas for four common 24-in disks having various curvatures when set at different angles.

Penetration of Disks

Packing of soil by disks and penetration are governed by the same group of factors. Since their relationship with packing has been discussed quite fully, it is only necessary to point out briefly their effect on penetration. Weight is the most important factor in penetration. Since the bearing

TABLE 2. BEARING AREA ON CONVEX SIDE AND PRESSURE AREA ON CONCAVE SIDE OF 24-IN DIAMETER DISKS HAVING VARIOUS RADII OF CURVATURE WHEN OPERATING 6-IN DEEP AT ANGLES SHOWN

Angle θ (deg)	Bearing area (in²) — Convex side				Pressure (Area, in²), concave side
	$R=21.07$ in	$R=25.50$ in	$R=28.74$ in	$R=37.00$ in	
0	10.00	7.80	6.76	5.12	0
5	6.44	4.32	3.52	1.96	8.80
10	3.60	1.64	1.12	0.20	15.40
15	2.16	0.80	0.48	0.16	20.68
20	0.80	0.12	—	—	30.24
30	—	—	—	—	43.76

on the convex side of the disk has been found to be an important factor in compaction, it follows that, when the angle of travel (ϕ) is less than the tangential angle (θ) at the ground surface, there is a definite bearing on the back of the disk resisting penetration. As pointed out in relation to packing, the bearing area and consequently penetration may be materially affected by the method of sharpening and the thickness of the disk. As the setting of the disk is changed so that ϕ becomes greater than θ, the curvature of the disk causes the soil to move upward along its path across the disk surface producing the "suction" effect of an inclined plane. This penetrating action can be increased by inclination of the disk, but, with the attendant compaction by the back of the disk at small values of ϕ, this would not seem to be advisable. The more common method of increasing penetration is by cutting notches in the disk to reduce the area of bearing at the circumference, thus increasing the penetration efficiency of the weight.

The Rotation of Disks and Stability

The disk differs from other tillage implements in that it in part substitutes rotation on a lubricated bearing for the friction of soil slipping across its surface. Its behavior varies from that of a circular "scrape" or chisel-like cutter to that of a wheel, depending largely on soil conditions and setting. The features of design which have been discussed under compaction and penetration are, of course, the same ones that affect rotation and stability, but when studied in this connection throw additional light on disk behavior.

In order to arrive at an understanding of the effects of the design and operation variables on rotation of the disk and its stability, two sets of model disks were made from aluminum plate. The first set was 8 in in diameter and consisted of six disks—one flat and five others having radii of curvature of 5, 7, 9, 11, and 13 in, respectively. These were sharpened on the back or convex side. They were run at a slow uniform speed (3 fpm) in moist (Lakeland) sand at bulk densities varying from 1.35 g/cc to 1.70 g/cc, and at different values of angle ϕ, from 5 to 45 deg. The number of shear planes were noted, and width of cut, throw, and travel per revolution of the disk were measured. The shear

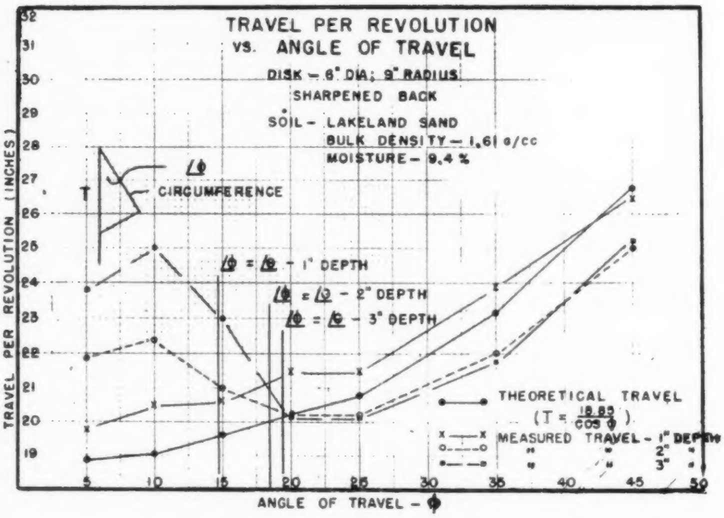


Fig. 8 *(Left)* Travel per revolution versus angle of travel. Disk sharpened on back produced greater bearing area, which reduced rotation, especially when angle ϕ is less than angle θ

planes were of quite constant dimensions for all values of radius of curvature studied, and it was concluded that the number and spacing of the planes depended almost wholly on the physical properties of the soil.

When the angle θ of the plane of the disk edge with the line of travel is equal to or greater than angle θ (the angle between P and the tangent at the soil surface, Fig. 6), all of force of resistance of the soil is exerted on the concave face of the disk, and the relationship of rotation of the disk to forward travel is shown in Fig. 7. The ratio of forward movement to rotation was found to be a function of the angle ϕ and that one revolution or circumference *(C)* would have the relation to forward travel *(T)* indicated by the equation $T=C/\cos\phi$. This was found to be true within the limits of experimental error for all cases where all factors other than values of θ were held as constant as possible. This condition does not hold when there is pressure on the back or convex side. In all cases pressure on the convex side produced results such as shown in Fig. 8, where the additional friction caused by this pressure on the back slowed down the rotation of the disk, giving greater travel per revolution. This effect occurs in all cases where ϕ is less than θ. When ϕ is greater than θ, it was found that $T=C/\cos\phi$ was within 10 percent of the travel obtained experimentally.

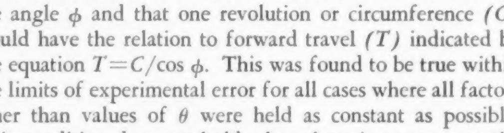


Fig. 9 Travel per revolution versus bulk density of soil. The relationship follows the equation: Log $T=K\times$ (bulk density). Values of K may vary for different soils

Where ϕ is less than θ and when there is appreciable bearing on the back of the disk, it behaves like a wheel. McKibben (7) explains this behavior in his studies of the rotation of a wheel over a non-elastic friable surface. He found experimentally, and explained mathematically, that "the non-elasticity of such a medium particularly under tensile stresses caused the compression of the material ahead of the wheel to be cumulative on a shortened surface. The distance traveled under these conditions during one revolution is greater than the length of the rim circumference."

Fig. 9 shows the effect of bulk density on travel. This relationship was obtained by measuring the travel per revolution of an 8-in disk having a 9-in radius of curvature. In general, firm dense soil reduces the rotation of the disk—*i.e.*, there is greater slippage when running at an angle, but much more work is needed to fully explain the relationship of various densities to disk behavior.

Summary

Disk tools are major tillage implements, with their use in primary plowing increasing. The most significant improvements will probably come from a better understanding of soil-implement relationships. Many questions have been proposed for study, with the goal in mind of reaching a sound scientific basis for design and use. Much work has been done, but the published results show few attempts in evaluating the effects of disking on soil physical properties.

The common disk is a section of a hollow sphere, with the physical dimensions of the disk and the soil physical conditions affecting the action of the disk and forces involved. Mathematical equations for the total normal pressure on the inner and outer faces of the disk have been developed. Forces in the L, S, and V directions can be measured with suitable equipment, such as that at the USDA Tillage Machinery Laboratory.

The disk penetrates and breaks the soil by pressure, with some cutting, pulverizing, inversion, and lateral movement of the soil. Weight is a major factor in penetration, and its effectiveness is governed by the setting and physical characteristics of the disk. Vegetative residue, rocks, and stumps are frequent factors of local importance in penetration.

(Continued on page 820)

A Runoff Sampler for Large Watersheds

Part II. Design of Field Installation

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Member ASAE — Assoc. Member ASAE

Based on laboratory tests of the hydraulic characteristics of a slotted conduit, intersecting the nappe of the flow through a drop-spillway structure, the authors discuss in this paper how results of these tests were used to design a runoff sampler for large watersheds

A TECHNIQUE of runoff sampling employing a sharp-edged slot extending downstream from the crest of a notch spillway was described in Part I of this paper (1),* which also presented the hydraulic characteristics of such a sampler. In this second part of the paper the knowledge of these characteristics is used as a basis for the design of a sampler for field use. Reference should be made to Part I for the notation used herein.

Selection of the Sampler Cross Section

Model 10, described in Part I of this paper, caused the least distortion of the flow and gave the smallest sample. Unfortunately model 10 was extremely difficult to fabricate and had a very thin section near the slot which was highly susceptible to mechanical damage. Model 11 gave a fairly small distortion to the nappe and in addition was relatively easy to fabricate and had a strong section near the slot. For these reasons model 11 was selected to serve as a model for the prototype sampler.

Development of the Constant Aliquot Sampler

One of the essential requirements set for the sampler was a constant ratio of sample taken to total flow, over varying rates of flow. The laboratory studies showed that a slot of uniform width did not meet this requirement. However, the results did indicate that the width of the slot might be varied along the length of the sampler in such a manner as to compensate for the increase in S (ratio of discharge through the notch spillway to discharge from the sampler) with increasing values of d_c/b_s (ratio of critical depth of flow through the notch spillway to width of the sampling slot).

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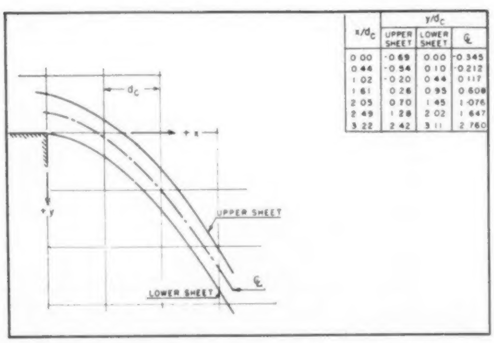
The authors—KENNETH K. BARNES and H. P. JOHNSON—are, respectively, professor of agricultural engineering and research associate, Iowa Agricultural Experiment Station.

*Numbers in parentheses refer to the appended references.



x/d_c	y/d_c Upper sheet	Lower sheet	℄
0.00	-0.69	0.00	-0.345
0.44	-0.54	0.10	-0.212
1.02	-0.20	0.44	0.117
1.61	0.26	0.95	0.608
2.05	0.70	1.45	1.076
2.49	1.28	2.02	1.647
3.22	2.42	3.11	2.760

Fig. 1 Dimensionless plot of the nappe from a level-floored flume

Analysis. Fred W. Blaisdell (2), of the U.S. Soil Conservation Service, supplied information on the shape of a free nappe resulting from flow conditions similar to those used in the experiments presented in Part I. This information agreed closely with results obtained by the authors and is presented in modified form in Fig. 1. From a logarithmic plot of the centerline of the nappe it was determined that the center line could be closely approximated by

$$y=0.467\frac{(x^{1.425})}{(d_c^{0.425})}-0.345d_c \quad [1]$$

A value of β (angle between the sampling slot and horizontal) of 10 deg was selected, and it was assumed that the upper end of the sampler would be placed 0.08 ft below the lip of the outlet. The location of the top edge of the sampler was thus described by

$$y=0.08+x(\tan 10^\circ)$$
$$=0.08+0.1763\,x \ldots \text{(see Fig. 1 for notation)} \quad [2]$$

Subtracting equation [2] from equation [1] and rearranging terms gives

$$0=0.467\,x^{1.425}-0.345\,d_c^{1.425}-0.1763\,xd_c^{0.425}-0.08\,d_c^{0.425} \quad [3]$$

the implicit relationship between d_c and the intersection of the center line of the nappe with the top edge of the sampler. A plot of x versus d_c from equation [3] indicated that

$$x=1.094\,d_c+0.131 \quad [4]$$

was a satisfactory approximation of equation [3] in the range of $0<d_c<3$.

The results of all tests on model 11 were then examined. The hypothetical value of $S=1$, when $b_n/b_s=1$, was added to the data, and the values for $b_n/b_s=255$ were ignored.

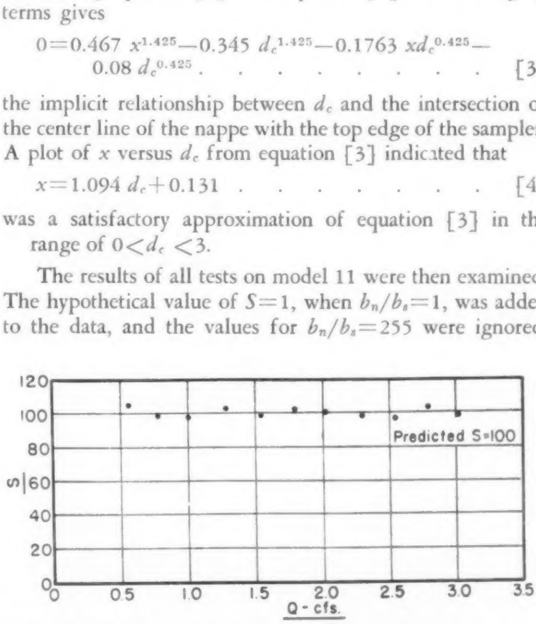


Fig. 2 Results of sampling tests of a diverging slot set to take 1/100 of the flow from a one-foot flume

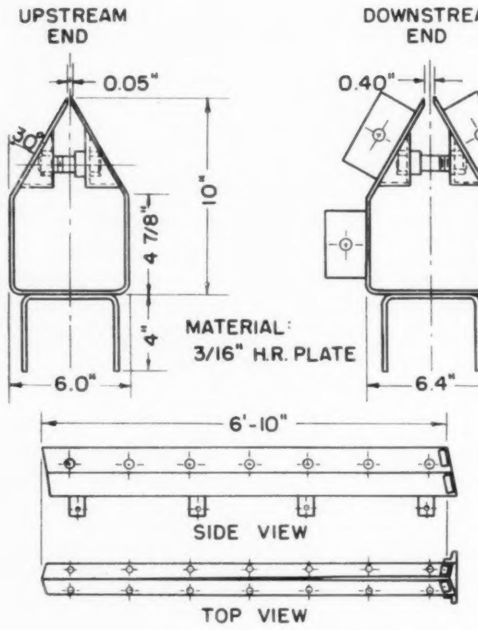


Fig. 3 Details of slot sampler

This omission of $b_n/b_s=255$ is justified on the basis that it is the only point for $\alpha=60$ deg which deviates greatly from a linear relationship between S and b_n/b_s (Part I, Fig. 12). These modified values for model 11 resulted in the relationship

$$S=0.33+0.491\ b_n/b_s+0.46\ d_c/b_s \quad . \quad . \quad . \quad [5]$$

Equations [4] and [5] where then solved simultaneously for b_s as a function of x and S to give, when b_n is unity,

$$b_s=(0.420x+0.436)/(S-0.33) \quad . \quad . \quad . \quad . \quad [6]$$

With this equation it was possible to determine b_s as a function of x for any desired value of S from a unit b_n.

Laboratory Test. Model 11 was adjusted to give a varying value of b_s in accordance with equation [6]. For this test S was taken to be 100. The model was then tested at $\beta=10$ deg through the range of channel flow available. The results of this test are presented in Fig. 2. The observed value of S ranged from 97 to 105, whereas the predicted value was 100.

Discussion. The laboratory results obtained with the constant aliquot sampler appeared to justify the design and installation of a prototype sampler. The value of $S=100$ was felt to be well suited to field design, as it represented the largest S which could be obtained without having b_s so small as to be impossible to gage accurately with the common feeler gages. The value of 10 deg was chosen for the angle of declination because it suited the field conditions for which a prototype was first to be tried.

Design of the Prototype Sampler

The first field installation of the single-slot sampler was designed for the drop spillway at station 23+00 of the main gully of the Theobold subwatershed, Woodbury County, Iowa. The drop spillway is a reinforced concrete notch 30 ft wide and 4.5 ft deep. The fall through the structure is 7 ft, and the apron protection is of the Morris and Johnson type. A water-stage recorder has been installed at this structure as part of the Iowa Agricultural Experiment Station research program in the Little Sioux River basin. The drainage area above station 23+00 of the main gully includes 762 acres. Peak runoff rates from this area are controlled by three detention reservoirs.

Functional Requirements. Basic functional requirements of the sampler in this installation were:

- To collect and store in a container of reasonable size a continuous sample of the flow through the structure.
- To collect and store this sample in such a way as to keep it free of contamination by back water or splash.

Actual runoff measurements from a very intense storm on this watershed were reported by H. P. Guy (3). A storm of June 15, 1950, on the Theobold subwatershed, which included an 80-year, 15-min rainfall at one station, gave a 70.7 percent runoff for the 309-acre area in which this station was located. Total runoff from the area above station 23+00 resulting from this storm was 1.13 in, representing

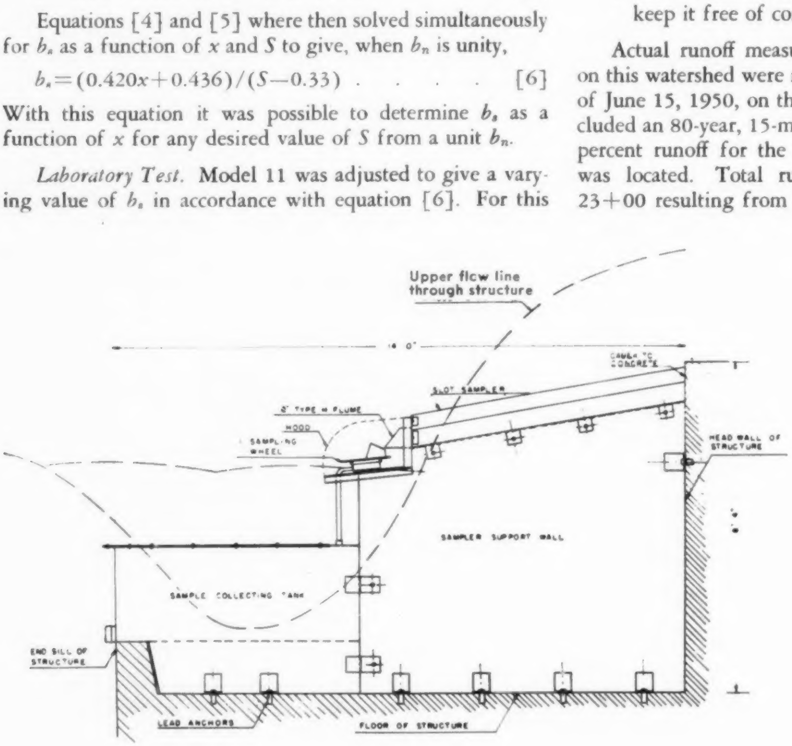


Fig. 4 Assembly drawing of slot sampler installation

a 62.2 percent runoff. Yarnell (6) gave the 24-hr 100-yr rainfall for western Iowa as 6 in. It was felt that a 50 percent runoff from such a storm would be high because of the relatively low intensity at which much of the precipitation would fall. Accordingly it was decided that storage for a sample from 3 in of runoff would be adequate, assuming that personnel could be present at least once every 24 hr during periods of high runoff.

Slot Sampler. The slot sampler for field installation was designed to take 1/100 of the flow through a one-foot width of the notch or, neglecting end contractions, 1/3000 of the flow through the 30-ft notch. Design discharge per unit width of the drop spillway is 26 cfs with a critical depth of 2.78 ft. Maximum critical depth in the laboratory tests was 0.635 ft. Design of the sampler without extrapolation from laboratory tests would have necessitated use of a scale factor of $2.78/0.635=4.4$. This would have meant a field design to take 1/100 from a 4.4-ft width of the notch. Since it was desired to keep the sample size to a minimum, it was decided to design for 1/100 from a one-foot width. This necessitated extrapolation from the laboratory tests.

The slot sampler for the field installation was designed as shown in Fig. 3. The slot width was determined in accordance with the equation [6] with $S=100$. Cross bolts were provided for fine adjustment of the slot width.

Pomerene Wheel. The slot sampler designed to take 1/3000 of a 3-in runoff from the watershed under consideration would yield a sample of 2760 cu ft. This volume required further reduction by a factor of 100 to be of reasonable size to save.

Various sampling devices mentioned in Part I were considered for application to reduction of the sample taken by the slot sampler. Of these devices the Pomerene wheel seemed best adapted for this purpose. Parsons (5) described a one-foot wheel calibrated for use with a 6-in H-type flume which appeared to be particularly well suited to this application. This wheel and flume were adapted for use with the slot sampler as shown in the assembly in Fig. 4. A hood was provided over the wheel and flume, and the flume was fitted to the slot sampler through a transition plate.

Collecting Tank. The tank provided for holding the sample delivered by the wheel is 6 ft long and 2½ ft wide. A streamlined shape was provided to minimize disturbance of flow through the structure. The capacity of the tank is approximately 27 cu ft. The cover is bolted on and is sealed with caulking compound to prevent contamination of the sample by the channel flow.

Since full capacity of the tank is needed only for extreme storms, a garbage pail was placed inside the tank to catch the sample from small runoffs. A covered manhole in the lid of the large tank permits removal of the garbage can without removing the entire tank cover.

Support Wall. Vertical placement of the sampler was planned after reference to flow patterns through similar structures presented by Morris and Johnson (4). These patterns were verified by tests conducted by the authors in the local laboratory. The support wall was designed to hold the slot sampler and the sampling wheel above any splash from the stilling pool. The uppermost limit of the nappe and of any splash from the stilling basin has been superimposed on the assembly drawing of Fig. 4. The support wall was designed to prevent any trash from lodging behind the sample collecting tank. The entire assembly was designed to be fastened to the notch spillway structure with lead expansion anchors.

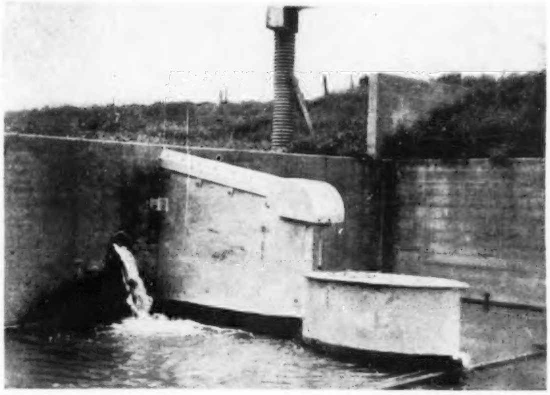


Fig. 5 Slot sampler installation at station 23+00 Theobold subwatershed area near Anthon, Iowa

Field Observations

The sampler assembly was installed in the field as shown in Fig. 5. The first runoff periods after field installation of the sampler revealed some trash-clogging problems which had not been evaluated in the laboratory. Certain weed seeds in the runoff were of such diameter as to become lodged in the sampling slot and thus distort the sampling characteristics. After this difficulty was observed the slot width was doubled recognizing that this might result in overtaxing the capacity of the storage facilities in heavy runoff periods. Since this modification was made trash has not been a serious problem. Velocities entering the H flume were found to be excessive. This was corrected by addition of a series of baffles. Placement of baffles was determined by trial and error in the laboratory. The baffle placement is shown in Fig. 6. The addition of these baffles gave satisfactory entrance conditions for the H flume at all stages of flow.

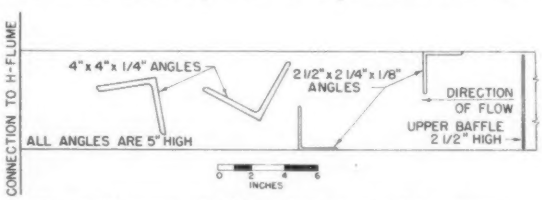


Fig. 6 Placement of baffles at discharge end of slot sampler

Table 1 includes the results from storms occurring in 1953 and 1954 which caused appreciable runoff. Sampling

TABLE 1.

Date	Vol. runoff, ft³	Vol. of sample, ft³	Vol. of sample per 100,000 ft³ of runoff	Max. depth over spillway, ft
7 June '53	283,700	1.44	0.51	0.56
30 May '54	83,900	0.51	0.61	0.30
2 June '54	494,500	3.12	0.63	0.58
20 June '54	3,020,000	26.38	0.87	2.25
2 Oct. '54	427,000	4.50*	1.00	0.74

*Leakage may have occurred around drain cap since previous cleaning of the tank.

(Continued on page 824)

Wear Tests of Plowshare Materials

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The fact that the annual consumption of plowshares is in the millions, and that plowshare maintenance constitutes 10 to 20 percent of plowing cost, prompted the setting up of a research project to investigate the role of alloying elements — especially carbon — as a factor in wear resistance, and to determine the suitability of nodular iron, in comparison with ordinary chilled iron, as a material for plowshares

WEAR of tillage tools, especially plowshares, has been one of the farmer's foremost problems from the time when he used a crooked stick plated with iron to present modern plows equipped with "razor-blade" plowshares. Gallwitz (2)* calculated that every year over 5,000 tons of steel and iron are lost in German agricultural soils due to wear of plowshares. In the United States it has been estimated that the cost of plowshare maintenance constitutes 10 to 20 percent of the plowing cost. In Michigan alone, because of the abrasive nature of the soil, about one-half million plowshares are used annually. Thus the problem of plowshare wear is obviously an important one.

The available information on the wear of metals in soils is quite meager. Among the most outstanding contributions in this field are the works of Gallwitz (2) in Germany, Tetsutaro Mitsuhasi et al (6) in Japan, Zink, Sellers and Roberts (7) and Reed and Gordon (5) in the United States.

The work at Michigan State University started in 1950 when a project was set up to investigate the role of alloying elements, especially carbon, as a factor in wear resistance, and to test the suitability of nodular iron as a material for plowshares.

Large Scale Field Tests

Approximately two hundred 14-in plowshares were cast in the University foundry. These were of various carbon contents and with various inoculants for controlling chill at the cutting edges. The problem of maintaining the same depth of chill in all comparative shares was a serious problem. Shares could not be classified as to whether their wear resistance was due to chilled depth variation or to composition unless the depth and quantity of chill on all the shares in any test was the same.

To select shares with the same chill pattern but from different heats and composition, three of the ten plowshares poured with each heat were sectioned according to the pattern shown in Fig. 1. When three chill patterns of three heats could be matched closely, the shares poured adjacent to these broken shares were selected for comparative wear tests. Out of the 200 shares cast only five sets (three shares to each set) could be selected for mounting on a three-bottom plow. Table 1 shows the results of the five tests conducted on these experimental shares. These data show,

TABLE 1. RESULTS OF LARGE-SCALE FIELD TESTS OF CAST IRON PLOWSHARES

Test Period hrs.	Share No.	Carbon	Loss: Whole plowshare (grams)	Loss: Cutting edges (sq. cm.)
	P20-6	LC*	312	24.2
7.5	P16-4	HC†	353	18.4
	P20-7	LC	289	21.6
	P16-6	HC	258	11.6
5	P19-9	LC	222	14.2
	P15-3	HC		11.6
2.5	P-16-3	HC	187	5.8
	P19-3	LC	172	17.4
	P3 D10	HC	311	15.5
6	P1	HC	304	18.3
	P4 B4	LC	223	15.1
	P2 D10	HC	560	22.6
6	P4 A2	LC	377	25.2
	P3 A1	HC	363	18.7

*Low-carbon iron with 2.85 to 2.95 percent carbon.
†High-carbon iron with 3.5 to 3.7 percent carbon.

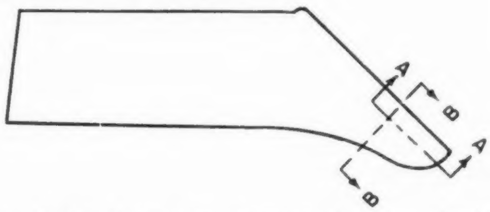
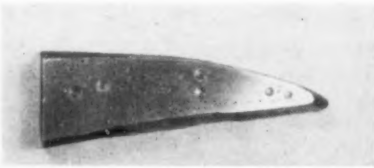


Fig. 1 Method of sectioning the points of cast-iron plowshares for comparison of chill patterns



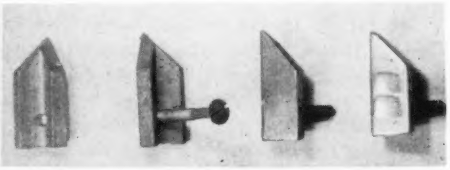


Fig. 2 *(Left)* Section A-A of Fig. 1 showing the chill pattern. Brinell hardness from left to right: Gray iron, 255; mottled iron, 320; white iron, 450 • Fig. 3 *(Right)* Miniature plowpoints. From left to right: Pattern, as cast, ready for field test, and after field and laboratory tests

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*Numbers in parentheses refer to the appended references.

when only the loss of white iron at the cutting edge is considered, in most cases the high-carbon iron proved to be superior or at least equal in wear resistance to the low-carbon iron. Additional discussion of the significance of this statement is given under the subheading "Correlation Between Laboratory and Field Data."

Accelerated Wear Tests

Realizing the limitations of weather, time, and soil variability involved in evaluating wear of tillage tools in the field, it was decided that a laboratory wear test method was needed which would give a satisfactory correlation between the results of the field tests and the laboratory tests.

To establish such a correlation it was felt necessary to devise a wear test in an intermediate stage between the laboratory conditions and the actual plowing conditions. This intermediate stage, which will be referred to as the small-scale field test, was designed in such a way that a large number of specimens could be subjected to the same tilling conditions in a comparatively short time.

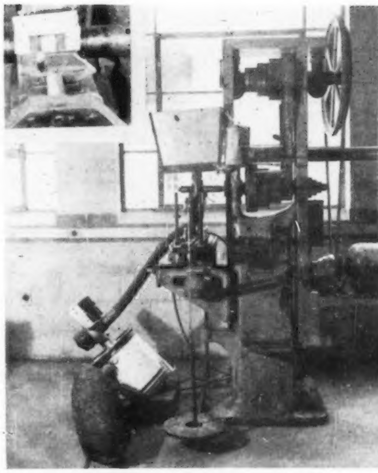

Fig. 4 *(Left)* General view of the wear-test machine. Inset shows the specimen held in place, the plastic window and the rubber belt on the rotating wheel • Fig. 5 *(Right)* The cultivator adapted for small-scale field tests

Test Materials

Experimental samples were made from 11 types of irons to include ordinary cast iron and nodular iron of high carbon or low carbon and alloyed or unalloyed compositions. The specimens were made both in chilled and unchilled conditions. The principal alloying elements were chromium, nickel, and molybdenum. The chemical analyses of the irons are shown in Table 2.

Test Samples

Fig. 3 shows the experimental plowpoints before and after field and laboratory tests. These specimens were 2⅞ in long, 1 in wide, and ⅜ in thick. The specimens had to be thick enough to stand the impact encountered in the field and yet thin enough to permit a complete and uniform chill throughout the sample. The weight of the specimens (about 180 grams each) permitted the use of an analytical balance for weight loss determinations.

TABLE 2. SUMMARY OF THE CHEMICAL ANALYSES OF THE IRONS USED IN THE CASTING OF THE MINIATURE PLOW POINTS

Element	Low carbon	High carbon	Nodular iron
C	2.9	3.6-3.7	3.6-3.7
Si	1.7-1.9	1.3-1.6	2.7-2.9
Mn	0.80	0.77	0.40-0.50
P	0.11	0.12	0.015-0.035
S	0.07	0.07	0.01-0.02
Ni	0.96	0.99	0.10-1.00
Cr	0.36	0.38	0.10
Mo	0.24	0.26	0.05
Mg	—	—	0.05-0.06
Cu	—	—	0.13-0.16

NOTE: The amounts of alloying elements used were relatively small so that the cost will not be prohibitive. In addition, these amounts can be added at the cupola spout without necessitating a departure from the ordinary melting equipment and foundry practice.

To verify a uniform microstructure in the cross section of each experimental plowpoint, a representative sample of each group of irons was sectioned, polished and etched for microscopic examinations. The microstructure of all the specimens consisted of a pearlitic matrix with carbon in the form of massive cementite in the chilled irons, type A and type B flake graphite in the unchilled irons, and nodules in the unchilled nodular irons.

Laboratory Wear-Test Machine

The laboratory wear-test machine used in this work was similar to the Brinell wear-test machine (4). The principles involved in this method of abrasive wear test have been described schematically in references (4) and (5).

Upon using the abrading steel disk recommended by Brinell it was noted that the wear appearance was much different from that which occurred on that same material in an actual field test. Authorities on wear agree (3) that the appearance of the specimen at successive stages of wear in the test ought to be indistinguishable from that of the same material at the same stage in service. In order that the wear appearance in the laboratory be made to more nearly resemble that in the field, a rubber belt was added around the periphery of the steel disk. The belt resulted in a cushion action to the sand particles striking the surface of the test specimen. This cushion action, which was probably similar to the action of soil on the surface of tillage tools, aided in producing a wear appearance of considerable improvement over that of the steel disk used without the rubber belt.

Another advantage of the rubber belt was the lack of high pressure on the individual abrasive particles, since the resiliency of the rubber permitted the particles to become imbedded in the face of the belt. In contrast, when a steel disk was used with sand, the latter was pulverized as it was carried between the specimen and the steel disk.

Fig. 4 shows the general view of the wear-test machine used in this study. The spindle of a milling machine was used to drive a steel disk ½ in thick and 4 in in diameter. The previously mentioned soft-rubber belt was changed after each twenty tests. Dry sand, flowing down the hopper, was

carried between the rubber face of the rotating wheel and the test sample. The sample was held against the wheel by a load hanging from the milling-machine table. The sand and dust were carried away by a suction fan. The test sample could be moved to and from the abrading wheel by means of a carriage mounted on four ball bearings and sliding in and out in the slots of the milling-machine table. A plastic window provided a means for watching the flow of sand (Fig. 4 inset).

In this way, a uniform flow of sand was assured by manipulating a control gate under the hopper.

The loss of weight was determined by weighing the specimen before and after the test on an analytical balance which read to one-tenth milligram. Four replicate tests were made on each specimen and the average of the four tests was reported as the weight loss under the laboratory conditions.

A number of exploratory tests were made to determine the effect of several variables which might affect the performance and reproducibility of the machine. The sand-particle size was found to be the most critical factor affecting reproducibility. A combination of a wheel speed of 275 rpm (peripheral speed about 3½ mph), a weight of 20 lb, a time period of 1½ min, and dry mortar sand (28 to 100 mesh) was found to give results which deviated not more than 5 percent from the mean of four tests on each sample.

Small Scale Field Tests

A 12-point cultivator was adapted for the small-scale field tests (Fig. 5). To check the reproducibility of weight losses in the field, a series of tests was conducted with twelve similar samples which were rotated periodically during the test. The use of this apparently controlled method of wear test resulted in variations of weight losses exceeding 200 percent.

Obviously no reliable comparative wear data could be obtained with such large variations in wear for similar materials. Variables in the test conditions are characteristic of agricultural soils and are beyond the operator. The only solution to the problem appeared to be randomized placing of the plow-points on the cultivator according to a statistical design, and interpretation of the data by analysis of variance.

Test No.	1	2	3	4	5	6
Position / Sample No.	1	3	5	7	9	11
1L	C	E	Q	A	P	J
2L	Q	A	J	P	E	C
3L	E	J	A	C	Q	P
4L	J	P	C	E	A	Q
5L	P	Q	E	J	C	A
6L	A	C	P	Q	J	E

Test No.	1	2	3	4	5	6
Position / Sample No.	2	4	6	8	10	12
1R	J	P	A	Q	C	E
2R	E	J	Q	P	A	C
3R	P	Q	C	A	E	J
4R	C	E	P	J	Q	A
5R	A	C	J	E	P	Q
6R	Q	A	E	C	J	P

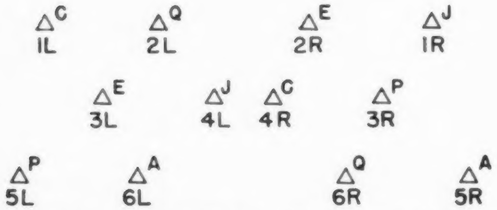

Fig. 6 Final arrangement on the chilled iron plow points in the 6x6 Latin squares. The lower part of the diagram shows the positions of the plow points on the cultivator for test No. 1

TABLE 3. RESULTS OF SMALL-SCALE FIELD TESTS AND CORRESPONDING LABORATORY TESTS ON THE SAME SAMPLES

Description of the iron	Mean weight loss Field (mg/cm²)	Lab. (mg)
Field test series No. 2		
Chilled high-carbon unalloyed	10.62	5.39
Chilled high-carbon alloyed	10.70	6.16
Chilled high-carbon nodular unalloyed	13.23	6.24
Chilled low-carbon unalloyed	13.50	7.30
Chilled high-carbon nodular alloyed	14.05	8.37
Chilled low-carbon alloyed	15.40	8.53
	r* = 0.89	
Field test series No. 3		
Unchilled high-carbon nodular unalloyed	78.50	30.71
Unchilled low-carbon alloyed	81.07	38.24
Unchilled low-carbon unalloyed	89.64	49.05
Unchilled high-carbon alloyed	92.73	51.92
Unchilled high-carbon unalloyed	115.00	61.48
	r* = 0.93	
Field test series No. 4 (right side)		
Chilled high-carbon nodular unalloyed	12.00	7.25
Chilled low-carbon unalloyed	13.57	7.25
Unchilled high-carbon nodular unalloyed	39.38	28.66
Unchilled low-carbon alloyed	43.89	38.54
Unchilled low-carbon unalloyed	49.87	46.78
	r* = 0.98	
Field test series No. 4 (left side)		
Chilled high-carbon alloyed	17.76	6.60
Chilled high-carbon unalloyed	18.67	5.86
Chilled high-carbon nodular alloyed	22.45	9.59
Chilled low-carbon alloyed	25.04	7.69
Unchilled high-carbon alloyed	83.13	53.70
	r* = 0.99	

r* = correlation coefficient

Latin Square Design

The total number of specimens used in each series of tests were arranged in two 6x6 Latin squares, one for each half of the cultivator. The rows of the squares represented positions of the plowpoints on the cultivator. The columns of the squares represented individual one-hour tests. The specimens were placed on the cultivator according to the scheme indicated by the two Latin squares. The final arrangement of the chilled specimens in the 6x6 squares and their relative positions on the cultivator for the first test in this series are shown in Fig. 6. After six one-hour tests, the weight losses were assembled into the Latin squares and analyzed.

In the Latin-square design, any treatment could occur once and only once in a row (position) or in a column (individual tests). This condition made it possible, as stated by Fisher (1), for each specimen to have an equal probability of receiving any of the possible treatments and each pair of specimens not in the same row or column to have the same probability of being treated alike.

Following the above scheme three series of field tests were conducted on a total number of 122 miniature plowpoints. After each series of field tests, the specimens were brought to the laboratory where they were subjected to laboratory wear tests.

Correlation Between Laboratory and Field Data

Table 3 shows the results of the three series of small-scale field tests and the corresponding laboratory tests. The calculated correlation coefficient, *r*, is indicated for each set of data.

The data from both the laboratory and the small-scale field tests show that the high-carbon ordinary chilled iron was superior to the low-carbon ordinary chilled iron. This result is in agreement with data showing the loss of chilled portions of the actual plowshares in plowing operations (Table 1).

When the weight loss of the whole plowshare is considered, the low-carbon share was superior to the high-carbon share. To help understand the significance of the previous statement the following facts should be considered: *(a)* a cast-iron plowshare is a composite material, *(b)* the greater portion of the share which wears out in service is made of gray iron, and *(c)* a low-carbon gray iron (as found in this work) wears better than the high-carbon gray iron. From the foregoing it appears that the better wear of low-carbon shares should be attributed to the better wear of low-carbon gray iron which constitutes more than 95 percent of the total share weight. This indicates that measurements of the weight loss of the whole composite share is not a true indication of the wear resistance of a plowshare in service. If the wear of the share at the point and the cutting edge were evaluated, the information would be more valuable in comparing the wear resistance of various types of irons.

Correlation Between Hardness and Weight Loss in the Field

The Brinnell hardness measurements of the 122 iron specimens and the correlation of these values with the corresponding weight losses in the field indicated a significant correlation in the case of unchilled irons. In the case of chilled irons the correlation factor was far from being significant. This inconsistency proved again that, since the wear resistance of metals also depends on the microstructure, hardness alone cannot be taken as an index of wear resistance.

The composition and degree of inoculation of the unchilled irons were such that their microstructures consisted of rather uniform pearlite and normal graphite. The hardness measurements in this case were correlated closely with the wear resistance of the irons because of this uniform structure. In the case of the chilled irons, variations in microstructure, which may have been caused by differences in distribution of iron carbide in the matrix of pearlite, were probably responsible for the lack of correlation between hardness and wear resistance.

A high degree of hardness seems to exert its influence on wear by preventing an abrasive from getting a "bite". If materials cannot dig into a surface, they simply slide off; hence the value of hardness. If the particles penetrate the metal surface, the property of ductility becomes important because the surface will flow under impact and will not crack and chip off as with a hard material. Since the weight loss of metal in soil is due mainly to the erosion of metal by cutting or scrubbing action of the abrasive material, it is thought that perhaps a scrtach test may give results of more practical value than the present methods of hardness measurement. The problem would be the design of a scratching device which reads directly the load units necessary to produce a groove of predetermined width across the metal specimen. In such a method, the stylus of the device would come in contact with a large section of the specimen and thus the effect of variations in microstructure would be minimized.

Summary and Conclusions

Analysis of the data leads to the following conclusions:

- Statistical analysis of the laboratory and field-wear test data resulted in correlation coefficients which were significant up to the 1 percent level. This high degree of correlation, plus the simplicity and the rapidity with which tests can be made, indicates the suitability of this method of wear test for the selection of tillage-tool materials.
- In an agricultural-engineering problem where control of all the field variables is almost an impossible task, proper statistical design of an experiment not only offers more reliable data and considerable saving in time and expense; it also provides a method for finding the best estimate for missing data for any of the specimens which may have been damaged or lost during the field operations.
- High-carbon chilled iron (no traces of flake graphite) proved to be superior to all the other kinds of iron. Low-carbon ordinary unchilled cast iron (no traces of massive cementite) was superior to all the unchilled irons, except nodular.
- An unchilled iron will wear four to five times as much as a corresponding chilled iron of the same composition and treatment under the same field test conditions.
- The effect of alloying elements was not significant in the chilled condition. However, the alloying elements contributed considerably to the wear resistance of the irons in the unchilled condition.
- Correlation between Brinell hardness of the iron specimens and weight loss in the field proved that hardness measurements alone cannot be taken as an index of wear resistance of cast iron in soil. It was proposed that a scratch test may be developed to give information on wear resistance of more practical value.
- Consideration of nodular iron as a material for cast-iron plowshares indicated that, if a plowshare is to consist of both chilled and unchilled irons, a high-carbon unalloyed nodular iron promises to be as good a material for this purpose as is available at the present time. This conclusion is reached on the basis of the experimental data and on consideration of the properties of nodular iron which include its moderate resistance to wear in the chilled condition, its high resistance to wear in the unchilled condition, its ductility and impact resistance, its property of developing a chilled surface of controlled depth, and its greater hardness in the unchilled condition which aids scouring of the plowshare.

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Agricultural V-Belt Development

(Continued from page 807)

methods and machines to produce it. The problem now being faced is the research required to produce machines that will more economically manufacture double-angle belts.

Most *traction* or *propulsion* drives, while they do involve high horsepower loads and are of a variable speed nature, are less severe. Development work has proceeded along more orderly lines from a solid background of industrial variable speed drives. Performance has reached satisfactory levels in almost all instances of agricultural self-propelled machines. The double cog-belt is considered as approaching the theoretical ultimate of V-belt design. It offers the highest pull-out torque of any V-belt made and is at the same time capable of withstanding maximum axial pressures. For its effective depth, it provides a higher degree of longitudinal flexibility than any other design.

In conclusion, the research and development engineers consider agricultural V-belt drives as having offered them the greatest challenge. Actually, other industries are indebted to the agricultural industry for the V-belt development it has fostered. V-belts today are capable of performance levels far beyond those of a comparatively few years ago. Continued research aided by the new materials and methods yet to come will produce products of even greater quality.

External Loads vs. Bolt Stresses

STRESS conditions vary for different types of joints according to a report by Russell, Burdsall & Ward Bolt and Nut Co., and are not always determined by external loads. In a rigid joint, where two hard surfaces are bolted together and may be considered a solid unit, external loading does not increase stress in the bolt unless the external load is greater than the residual tension in the bolt. The bolt should be torqued as near as possible to its yield strength to resist a maximum amount of external load without loosening.

In a flexible joint external loading adds to the tightening stress, thus the bolt stress is the sum of residual tension plus external load. The bolt should be torqued enough to prevent leakage, leaving the balance of its strength to take care of external loading. A flexible joint is described as one in which two soft surfaces are bolted together, or one hard and one soft surface are bolted together, or two surfaces separated by a gasket to prevent leakage are bolted together.

Geometry of Disks and Soil Relationships

(Continued from page 812)

After penetration is achieved, the disk compresses the soil until it breaks out in blocks ahead of the disk along the primary shear planes about 45 deg from the vertical. Upward and lateral movement caused by the spherical surface produce secondary shear planes roughly perpendicular to the primary planes. The resistance of the soil to penetration, compression, and shear are of importance as they determine the required weight, strength of frame, bearings, curvature of disks, speed and draft. Alloys and heat-treatments required are determined by soil abrasiveness, and soil-metal adhesion and friction govern surface finish.

Disk harrows have been believed to cause serious compaction and, since they depend on weight for penetration, this may be expected. Some evidence of this has been shown. If the setting of the disk is such that the back or convex side runs against the soil, the area in contact exerts pressure on the soil. Sharpening the disk with a bevel on the back side increases the bearing area. Total bearing area is determined by the radius of curvature, depth of cut, angle of travel, and method of sharpening. The principal forces acting on a disk are weight and forward pull, with their resultant (when corrected for friction and ahesion) equal to the soil reaction. The same pressure on a bearing area that effects compaction also determines the depth of penetration. As the bearing area increases, caused by a decrease in angle, penetration is reduced.

The disk is unique in substituting rotation on a lubricated bearing for part of the soil-metal friction. The action of a disk varies from that of a circular "scrape" to that of a wheel. Design features affect rotation and stability as well as penetration and compaction. Model disks were made and used to study qualitatively the effects of design variables. Six disks—one flat and one each of 5, 7, 9, 11, and 13-in radius of curvature—were studied in moist sand which clearly showed soil reaction. Speed of operation was constant but depth and angle were changed through a range of soil densities. When the angle of travel is such that no pressure is exerted on the back of the disk, the speed of revolution is a function of the angle. If the soil presses on the back of the disk, the rotation is reduced. Increased density of the soil also reduces disk rotation.

The points discussed must be verified by additional study and measurement of forces involved made to give quantitative values usable in designing better harrows:

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Development of a Sugar-Cane Harvester

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With extensive field studies as a background for establishing service requirements of a sugar-cane harvester for Louisiana conditions, agricultural engineers proceeded with the development of a machine that, even in the present stage, has attained a high degree of success in the field

THE principal sugar-cane area of Louisiana is located in the deep delta of the Mississippi River. The soil types range from fine sandy loam to clay and the condition of the soil may vary from dry and hard to wet and soft. In general, the land has poor internal drainage, and it is necessary to plant the cane 2 to 3 in above water-furrow level in ridges or beds 10 to 16 in in height, spaced 6 ft apart.

The cane seldom matures because of the annual freezes, and the crop must be produced and harvested in 7 to 10 months. The yield ranges from 15 to 35 tons of cane per acre with a state average of 24 tons per acre. Most of the canes are erect at harvesttime, except when lodged by rain and wind, as contrasted to canes in Florida which are recumbent and similar to good cane growth under tropical conditions.

At the beginning of the harvest the tops and most of the upper leaves are green and cannot be removed by burning before cutting as is the general practice in many cane areas of the world. In Louisiana, the present harvesting method consists of cutting the canes top and bottom, either by machine or hand, and placing them across the row ridges to form a heap or windrow (Fig. 1). Three to six rows are placed in the windrow. It is necessary to leave the canes in the windrow one to three days—depending on the weather—to dry the leaves sufficiently for burning. After burning, the canes are loaded into carts by means of tractor-mounted grab loaders for transport to the processing factory. Under normal conditions three to seven days may elapse between cutting and milling. Rainy conditions during this period may further delay milling and reduce the amount of recoverable sugar or sucrose. The amount of loss to the cane producer depends primarily upon the rate of inversion or change of sucrose (crystallizable sugar) to dextrose and levulose (non-crystallizable sugars) and the loss in weight due to moisture evaporation from the canes. Studies by Guilbeau, Coll, and Martin (1)* have shown that the loss of recoverable sugar can amount to 22 lb of sugar per ton of cane by nine days' delay in milling. Their results showed that the combined effect of inversion and moisture evaporation in nine days can cause a loss of $17.68 per acre.

In addition to these losses in delayed milling, the quantity and type of trash milled with the cane affect the recovery of sucrose. Dry trash, as encountered after a freeze, increases the amount of sucrose carried into the bagasse. Green trash increases non-sucrose solids which tie up sucrose, thereby reducing the recovery of sucrose and increasing the amount of molasses. According to studies conducted by Arceneaux and Davidson (2), the loss caused by trash may vary from 5.17 to 8.92 lb of sucrose per ton of cane. The combined effect of delayed milling and trash can cause losses to the producer and processor of 8 to 22 lb of sucrose per ton of cane. Based on these figures, fresh clean cane is worth $9.60 to $24.00 more per acre than cane most generally harvested by the present method.

Studies to determine distribution of sucrose and trash showed that the maximum amount of sucrose occurs at the butt and gradually decreases toward the top of the cane (Fig. 2). For example, in one field sample, the 0-12-inch zone from the butt cut contained 48 lb of sucrose per ton of clean cane as contrasted with 33 lb for the 48-60-in zone and 2.82 lb for the 84-96-in zone. The total computed sucrose per ton of clean cane was 249 lb. The computed recoverable sucrose was 205 lb. This sample contained better-than-average cane since the state average for recoverable sucrose is approximately 165 lb per ton.

The stooling characteristic of sugar cane results in a wide variation in length and maturity of the individual canes at harvest time. The stalks that made up the field

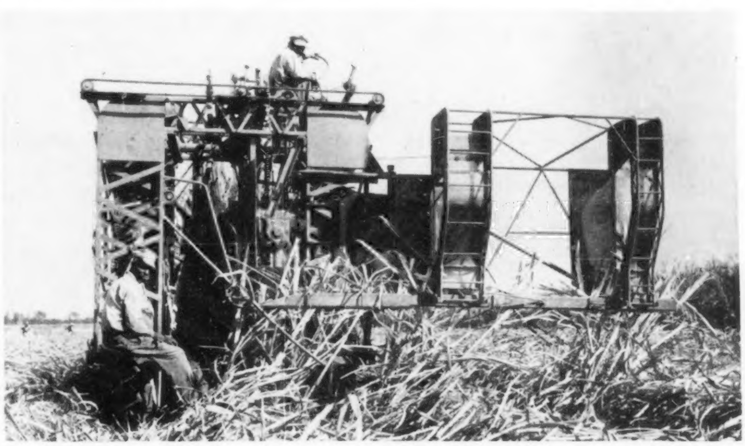

Fig. 1 Cutting sugar cane top and bottom and piling in a heap row with the present commercial cane-cutting machine

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Roanoke, Va., June, 1956, on a program arranged by the Power and Machinery Division.

The author—R. M. Ramp—is agricultural engineer, farm machinery section (AERB, ARS), U.S. Department of Agriculture.

Acknowledgment: The author expresses appreciation to Edith Champagne, Weston J. Domangue, Julius L. Martin, Joseph W. Morris, and Marvin E. Robinson of the project staff, and to George B. Duke, J. H. Herndon, and Harold A. Kramer, formerly assigned to the project, for their assistance in the development of the sugar-cane harvester.

*Numbers in parentheses refer to the appended references.

sample varied in length from approximately 36 to 102 in. The quantity of trash was low at the butt cut and increased to a maximum at the terminal zone of the canes. For example, the 0-12-in zone contained 10 lb of trash per ton of cane as compared with 27 lb for the 48-60-in zone and 114 lb for the 84-96-in zone. Above the 96-in zone the quantity of trash gradually decreased to 12 lb for the 144-156-in zone. The zone above 102 in is considered top and does not contain any recoverable sucrose.

At the beginning of the harvest season, 33 percent of the total weight is made up of trash in the form of leaves and tops. By the end of the season, approaching maturity and freezes reduce the total trash to approximately 25 percent. The whole sugar cane in the field sample mentioned above contained 9.96 percent trash in the form of leaves and 14.8 percent in tops. The cane top normally represents approximately two-thirds of the total trash. Average topping at 96 in, as used on the present commercial cane-cutting machines, would leave 313 lb of trash per ton of cane, or 15.6 percent to be removed either by burning or mechanical means.

From the above-mentioned and related studies, service requirements were established for a sugar-cane harvester. These requirements were formulated through the joint efforts of the Farm Machinery Research Advisory Committee of the American Sugar Cane League and the sugar-cane machinery project of the U.S. Department of Agriculture. They were as follows:

- The harvester shall be capable of cutting, cleaning, and loading sugar cane in one continuous operation.
- The harvester shall have a capacity of 10 acres per 9-hr day, or 200 tons.
- The average trash content of the harvested canes shall be 3 percent or less.
- The harvester shall be capable of opening a field without prior operations.
- The harvester shall be capable of cutting all the rows in a field.
- The harvester shall be capable of operating independently of the hauling or transport tractors.
- The harvester shall be capable of harvesting erect canes up to 50 tons per acre.
- The harvester shall be capable of operating under muddy field conditions.
- The harvester shall be capable of harvesting partially lodged canes.
- The harvester shall be economically practical.

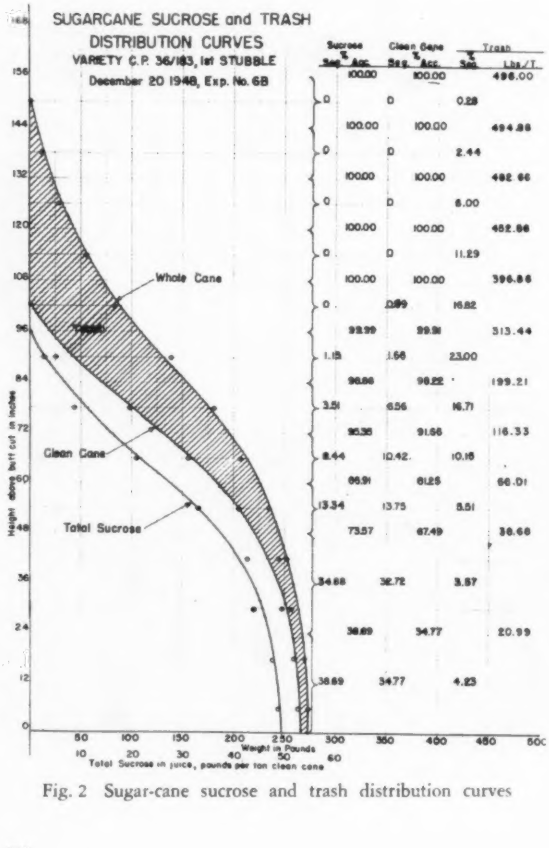

Fig. 2 Sugar-cane sucrose and trash distribution curves

This report pertains to the sugar-cane harvester development from 1949 through 1955. The first field machine was designed to provide a self-propelled unit upon which the various component units, such as cutting, elevating, cleaning, and loading, could be mounted for field testing. The front wheels of the unit were equipped with 18-26 special ground-grip rice and cane rubber tires with a 72-inch-tread width. These were driven by a 69-hp, six-cylinder, industrial-type gasoline engine through a variable V-belt drive and a modified three-speed transmission and axle assembly. The unit was steered mechanically from the rear wheels. The gatherers and the bottom and top cutters were mounted ahead of the front wheels. The bottom cutter consisted of an adjustable 36-in-diam blade mounted 11½ in off-center. A 13-in-diam topper blade was mounted directly on the output shaft of a 40-lb-in/100-psi hydraulic motor. This motor had a normal operating speed of 1200 rpm. A side conveyor installed early in the season disposed of the cut cane, permitting continuous operation of the harvester for evaluation of the cutting, gathering, and conveying components.

In 1950 the single-bottom cutter was replaced with two 35-in-diam overlapping blades to assure a more complete job of cutting all the canes at the butt with a minimum amount of lateral movement. Revisions were made on the upper and lower gatherers; however, the main emphasis was upon the removal of the trash from the upper part of the cane. Several types of stripping units that previously had been laboratory tested were mounted on the harvester and field evaluated. The most satisfactory unit from the standpoint of power and capacity consisted of two sets of cylinders equipped with flexible stripping fingers. The side conveyor was found unsatisfactory for loading the conventional cane carts because of tangling of the canes as they were discharged into the cart and because of the difficulties in synchronizing the cart to the harvester speed.

In 1951 a loading arm was developed which made it possible to load a cart attached to the rear of the harvester. The cart was provided with a tongue at each end to assist in the transfer from the harvester to the transport tractor. The tractor was equipped with an adjustable hitch for alignment of the wagon tongue. The loading arm and rear cart made it possible for the harvester to open a field without prior operations and to operate independently of the transport

tractor at the time of transfer. It was found from field operations that attaching the cart to the rear of the harvester made it difficult to turn at the end of the row, especially under muddy conditions. At the close of the season the loading arm was swung to the side for direct loading of a cane cart pulled alongside the harvester with the transport tractor. With this method of loading it was difficult to synchronize the harvester and carts, and the cane loads were not as compact as obtained with grab loading.

The chassis of the harvester was changed in 1952 from a front to a rear-wheel-propelled unit. This change improved the maneuverability of the harvester and provided for better turning under muddy conditions. The method of transferring the cart between the transport tractor and the harvester was the same as used in 1951. The time required for attaching and detaching the carts varied from 3 to 5 min and was not considered practical for commercial operation. From 1½ to 5 min were required to cut a ton of cane when operating at 1.8 mph. The harvested cane contained from 1.42 to 15.08 percent trash with an average of 5.7 percent.

In 1953 special four-wheel 6-ton capacity wagons were developed to reduce the time formerly required for attaching and detaching the cane carts. The wagon transfer, which formerly required two helpers and 3 to 5 min, was made by one helper in 30 sec. The additional wagon capacity made it possible for the harvester to operate longer between load transfers. The wagon was pulled by a cable attached to a truck winch located on the rear of the harvester. The loader operator was able to pay off cable for picking up the wagon, thereby eliminating the necessity of backing the harvester to attach a wagon.

Vertical adjustment was provided on the loading arm in 1954. This made it possible to lower the arm into the wagon for starting a load as well as providing extra wagon capacity by heaping the load. In addition to improvement in the cleaning and mechanical components of the harvester, a cylinder-type ensilage cutter head was mounted on the front of the harvester to determine the effect of cutting cane tops as a possible method of borer control. During a three-week period in December, 240 tons of cane were harvested. The trash content of the harvested cane averaged 6.32 percent, ranging from a minimum of 1.73 to a maximum of 11.56 percent. Studies showed that the ground loss of millable cane varied from 4.38 to 6 percent of the total yield per acre for borer-free erect cane. The ground loss for bored and wind-lodged cane varied from 10.22 to 14.85 percent.

During 1955 efforts were concentrated on improving the gathering and detrashing units. Satisfactory operation of

Fig. 3 Experimental USDA sugar-cane harvester equipped with conical type of gatherer

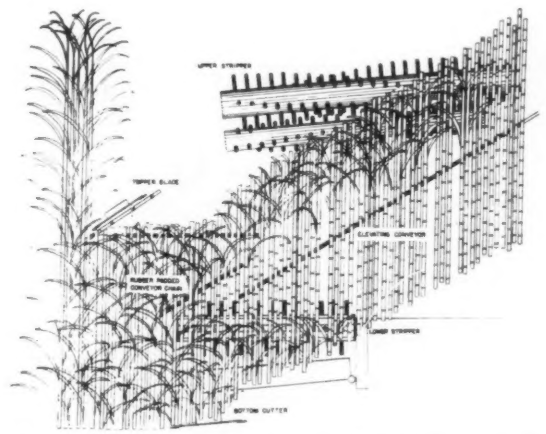

Fig. 4 Diagram illustrating the operation of the conveying, cutting, and stripping units of the sugar-cane harvester

the detrashing units depends to a large extent on proper patterning of the canes. For the most effective operation, the axes of the canes should be 90 deg with respect to the axes of the stripping cylinders. While most of the cane in Louisiana is erect, some lodged individual stalks, as well as lodged spots in the field, must be brought into a vertical position mechanically before they are conveyed into the detrashing units of the harvester. If the canes are erect, very little patterning and straightening are required and the simplest type of chain gatherer is satisfactory. The problem of lifting lodged canes into a vertical position is more involved since the canes may lodge in any direction in relation to the row. Canes lodged at right angle to the row can be raised to a vertical position with the chain-type gatherer; however, the ground speed at which they can be lifted without breakage is critical. The maximum ground speed is normally 1 to 1¼ mph., the exact speed depending upon the height of the canes as well as the pattern of lodging. If the canes are twisted as well as lodged, it is frequently necessary to reduce the forward speed to less than 1 mph. Excessive chain speeds pull the canes out of the ground or hairpin them over the lift fingers. In either case, the canes are lost or not properly fed to the harvester. Preliminary studies were started in 1955 to determine whether a new type of gatherer could be developed which would overcome the speed limitation of the chain-type gatherer.

A conical helix type of screw conveyor was developed and adapted in place of the lower gatherers. Each conical gatherer was mounted on a shaft supported at the rear and hydraulically controlled for regulation of the height at the front. An 18-in, double-pitch, ribbon conveyor was welded to the shell to assist in moving the canes along the cone. The conical-type gatherer as mounted on the 1955 experimental sugarcane harvester is illustrated in Fig. 3 . The horizontal component of the conical conveyor speed was maintained equal to the harvester ground speed. As long as the canes were lodged at right angles to the row, the conical gatherers lifted them vertically without shifting their position either forward or backward. However, when the canes deviated from the 90-deg position with respect to the cane row, the conical gatherer was not capable of speeding up or retarding the canes in relation to the forward travel speed

to bring them into a vertical position. The seriousness of this condition depended largely upon the magnitude which the bent canes departed from the erect position. If canes were lodged lengthwise of the row, either towards or away from the direction of travel, neither the chain nor the conical gatherers were satisfactory, and the ground loss was excessive.

Immediately after gathering, the tops were severed from the canes and discharged into the right-hand middle immediately ahead of the front wheel. The conveyor and stripping operations are illustrated in Fig. 4. Rubber-padded conveyor chains gripped the stalks before and during the butt-cutting operation and transferred them from the front gatherers to the elevating sticker chain. The stalks were gripped by the sticker chain approximately 40 in above the butt cut and conveyed upward and rearward through the stripping units. The lower stripper, located beneath the front section of the sticker, consists of two cylinders equipped with four rows of snap-in-type rubber fingers spaced 4 in apart in each row. The rubber finger is tilted negatively 15 deg from the radial line of the cylinder to reduce hairpinning and accumulation of trash on the fingers. The cylinders are located 14 in on center, thus providing 3¾ in of finger overlap. The cylinders are located horizontally on each side of the line of cane and are rotated to comb downward at a speed of 630 rpm as the canes are moved rearward and upward through the cylinders.

Simultaneously with the lower stripping operation the section of the canes above the sticker is engaged by the upper stripping unit. This unit consists of a pair of feed cylinders and a pair of stripping cylinders. The feed cylinders were fabricated from 6-in-diam, thin-wall steel tubing in which four rows of snap-in rubber fingers were spaced 4 in apart in the row. Each row of fingers was spiralled 90 deg for proper timing with the stripping cylinders. The cylinders were rotated to comb upward on the line of canes as they were moved upward and rearward by the elevating sticker. The stripping cylinders were fabricated from 8⅝-in-diam steel tubing and were equipped with four rows of snap-in rubber fingers. These cylinders were rotated to comb downward on the line of canes as the canes were moved upward and rearward. The combined action of the feed and stripping cylinders removes the leaves from the canes and discharges them to the side at right angles to the axes of the cylinders. After the movement of the canes through both lower and upper sections, they are transferred from the elevating sticker to the loader arm chain for conveyance to the wagon.

The trash content of the cane harvested from December 6 through 22 for 41 consecutive loads averaged 2.29 percent and varied from a minimum of 0.79 to a maximum of 9.73 percent. All the samples for which the trash content exceeded 5 percent contained suckers. The stripping unit giving this small amount of trash caused some cane breakage and increased the ground loss, particularly in borer infested cane. The total weight of the harvester was 15,500 lb. Power for propelling and operating the harvester is supplied by a 95-hp gasoline engine. Under dry field conditions the total power used varied from 55 to 65 hp. The harvester is equipped with hydraulic drives and controls, including steering.

The present and future experimental work will be directed toward improvement of the gathering and stripping units for more efficient gathering of wind-lodged or down cane and for more efficient stripping of borer infested or bent canes.

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2 Arceneaux, George and Davidson, Lester. Some effects of trash in cane on milling results. *Sugar Bulletin*, June 15, 1944.

Runoff Sampler for Large Watersheds

(Continued from page 815)

results at very low discharges (less than 0.1 ft deep over spillway) are poor because of clinging of the nappe and the inability to obtain an accurate adjustment of the sampling slot.

Theoretically the sampler should collect 0.67 cu ft of runoff for each 100,000 cu ft of runoff. The storm of June 20, 1954, was the only storm to date which tested the sampler at an appreciable depth of flow. In this case the sampling percentage appeared to be about 30 per cent too large. Final evaluation of the apparatus for sampling runoff awaits further measurement of its performance in the field.

Summary

Results of laboratory tests of the hydraulic characteristics of a slotted conduit, intersecting the nappe of the flow through a drop-spillway structure, were utilized in the design of a runoff sampler for large watersheds. The equipment for the field installation includes a conduit extending downstream from the notch of a drop-spillway structure, a Pomerene-type sampling wheel which takes 1/100 of the discharge from the conduit, and a 27-cu ft tank for storage of the sample. The upper edge of the conduit has a sharp-edged slot bounded by surfaces which lie in planes parallel to the axis of the conduit and intersecting at an angle of 60 deg. This slot is 0.1 in wide at the crest of the spillway and diverges linearly to 0.8 in wide of 6 ft downstream from the crest of the spillway. The conduit is depressed 10 deg from the horizontal.

This apparatus was installed at a drop spillway at the outlet of a 762-acre drainage area in Woodbury County, Iowa, and field observations are under way.

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1 Barnes, Kenneth K. and Frevert, R. K. A runoff sampler for large watersheds. Part I. Laboratory Studies. AGRICULTURAL ENGINEERING 35 (2):84-90. 1954.

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3 Guy, H. P. Runoff report for selected storms on waterhseds near Anthon, Iowa. (unpublished report) Iowa Agr. Exp. Sta. 1950.

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5 Parsons, D. A. U. S. Soil Cons. Ser., St. Anthony Falls Hydraulic Laboratory. Information on sampling wheels. (private communication) 1950

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TECHNICAL PAPER ABSTRACTS

Following are brief reviews of papers presented at ASAE meetings. Information concerning complete copies of these papers may be obtained by writing to the American Society of Agricultural Engineers, St. Joseph, Mich.

The Development of the Mechanical Cotton Stripper, by Harris P. Smith, professor of agricultural engineering, A & M College of Texas, College Station. Presented at the annual meeting of ASAE at Roanoke, Va., June, 1956, on a program arranged by the Power and Machinery Division. Paper No. **56-36.**

Development of the mechanical cotton stripper from its early conception to its use today is covered in this paper. Even though most of the mechanical cotton strippers now in use were developed during the past 15 years, the basic principles were patented during the last one-half of the 19th century.

The basic mechanical principles used in stripping cotton bolls from the plants include: (a) belts or aprons equipped with short teeth or long fingers, (b) interlocking lugs or fingers attached to inclined traveling chains, (c) stationary comb-like fingers, (d) smooth, feathered or pin-studded steel rollers and (e) rollers having a flexible surface made of bristles or a rubber compound.

The Texas Agricultural Experiment Station was the first public agency to start research work on the development of the mechanical cotton stripper. The work of the station engineers has resulted in the development of the smooth-type and the rubber paddle-type stripper rolls, the tapered auger for the conveying of stripped cotton, a tractor-mounted bur extractor that eliminates most of the green bolls and a vertical seed cotton cleaner. The studies by the station engineers also have revealed that the performance of mechanical cotton strippers is influenced by plant characteristics, soil and climatic conditions, cultural practices, type of stripping unit, date of harvest and the carefulness of the operator. Data are presented to show cost advantages for machine harvesting over hand harvesting.

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Rehabilitation of Interior Lands, by W. J. Endersbee, office of the secretary, U. S. Department of Interior. Presented at the annual meeting of ASAE in Roanoke, Va., June, 1956, on a program arranged by the Soil and Water Division. Paper No. **56-39.**

This paper reports on a 20-year management and conservation program that has been conducted on lands under the jurisdiction of U.S. Department of Interior. These lands consist of over 273 million acres in the United States and 290 million acres in the Territories.

Management is affected by the location, condition, and the purpose for which lands are used, as they affect rehabilitation. The areas reviewed include interior lands in 45 of the 48 states. Much of the land is in areas of low precipitation and sparse vegetation, which nobody wants and in general no individual could afford to own.

There are 56 million acres of Indian lands that have been damaged by misuse, and nearly 17 million acres of national parks. Also, 9½ million acres have been set aside as refuges for the protection of wildlife, and there are 9½ million acres of land withdrawn and reserved for reclamation, power sites, and other purposes. The U. S. Department of Interior is working toward the rehabilitation of the lands which are in poor condition, through proper management and application of conservation measures.

The author lists some of the accomplishments of the department in its effort to bring the land to productivity. Two and one-half million acres have been seeded to grass since 1940; another 2½ million acres have been restored to grass by eliminating useless brush. Wind erosion control is accomplished by planting a legume before harvest which is left in the ground to be turned under the following spring.

Water conservation is just as critical as soil conservation. Stockwater is not developed where vegetation is sparse, but is provided where there is food to be served. Deep pit charcos are built to reduce surface evaporation and structures are installed to control erosion and improve soil moisture. Progress has been made in arresting damage and improving management, but improvement is not keeping pace with damage. In 1955 a 20-year goal had been established and congress has approved an increased budget to accomplish necessary conservation treatment.

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Highway Erosion Control Developments, by Frank H. Brant, landscape engineer, North Carolina State Highway and Public Works Commission, Raleigh. Paper presented at the annual meeting of ASAE in Roanoke, Va., June, 1956, on a program arranged by the Soil and Water Division. Paper No. **56-40.**

Highways are part of the agricultural communities through which they pass and cannot be independent of each other as water runoff from farm land damages highways, and runoff from highways damages farm land. The problem of resolving differences between highway and agriculture has not been solved, but the realization of the need for collaboration is in itself an important development in highway erosion control.

Highway erosion control requires collaboration of many branches of a highway department working together. Streamlined cross-section; adequate drainage; prompt coverage with vegetation; and continuing protection of the cover are important. Highway erosion control starts with the highway location party; it also starts with a newly-cleared field or with the beginning of a terrace, perhaps out of sight of the highway location.

In the past there was emphasis on flattening slopes and covering them with topsoil. In recent years there have been great changes in highway design; improved alignment and grades, wider cross-sections, dual construction. Flatter grades meant heavier cuts and fills, many being on steeper slopes than might be desired. Larger areas of subsoil were exposed; drought conditions were intensified; topsoil for the increased areas became an impossibility; drainage design more intricate. Newly completed construction is particularly susceptible to erosion, so the need for prevention rather than cure, and the speed-up to accomplish it is probably the most important recent development in highway erosion control.

Specialized equipment, such as tillage equipment for steep slopes, hydraulic seeders, and mulch blowers now have widespread use. Chemical mowing; compressed-air seeding equipment; sawdust as a soil amendment; pelleted seed, pelleted fertilizers, and asphalt emulsions as a mulch over new seedings are being tried. Slow-acting and long-lasting fertilizers should prove valuable; also seed treatment with fungicides to help good seed develop into vigorous plants. A persistent search continues to find or develop new grasses or legumes. Progress is being made in highway design that will help bring about better erosion control.

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Custom Built Rubber Products for Agriculture, by James R. Tate, farm products manager, Thermoid Company, Trenton, N. J. Paper presented at the North Atlantic Section Meeting of ASAE at Ithaca, N. Y., August, 1956, on a program arranged by the Power and Machinery Division. Paper No. **56-42.**

The development of a flexible neoprene fertilizer conductor for grain drills, corn planters, and side dressing equipment was discussed in this paper.

Numerous requirements such as weather and sunlight resistance, flexibility, resilience, anticlog, elongation and adaptibility must be considered in the development of such a conductor. A graphic chart was used to illustrate the choice of rubber utilized in the development of the conductor.

Two types of conductors are available namely: Type B which will elongate 400 percent of its compressed length for application where extreme elongation is required and type C which elongates 10 percent of its free length for side dressers and planters which require limited elongation.

The elongation is achieved by a continuation of annular rings which have an accordion effect when elongated and compressed. Three sizes have been produced 1$\frac{3}{16}$, 1½, and 1¾-in I.D. in both types. Special ends can be fashioned on the conductor to accommodate the casting and spouts of the individual pieces of equipment.

The paper contains a data sheet which outlines the sizes and complete details of neoprene fertilizer conductor.

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Mechanical Potato Harvesting and Bulk Handling in Maine, by H. D. Bartlett and D. H. Huntington, respectively, associate professor of agricultural engineering at Pennsylvania State University and assistant professor of agricultural engineering at the University of Maine. Paper presented at North Atlantic Section Meeting of ASAE at Cornell University, Ithaca, N. Y., August, 1956. Paper No. **56-43.**

Mechanical potato harvesters were used to harvest a substantial acreage of Maine potatoes during the 1955 season. This was the first season in which the harvesters were used to any extent in Maine and followed several years of developmental and promotional work by the Maine Agricultural Experiment Station. This paper describes the work conducted by the experiment station and discusses in detail the mechanical principles being employed by the various types of harvesters. Handling and transporting equipment, including barrel, bulk, and box handling are also discussed. The need for properly designed storage facilities is emphasized and specific suggestions are offered.

This paper also reports the results of a cost survey conducted during the 1955 season and provides data for comparing the conventional hand picking method of harvesting to the mechanical method. Specific recommendations are offered to prospective mechanical harvester owners. These include suggestions for field preparation, storage handling, varieties, tillage practices and crop management practices.

NEWS SECTION

Vice-President Vacancy Filled Temporarily

THE Council of ASAE has appointed T. W. Edminster to fill temporarily the vacancy of vice-president of ASAE created by the death of P. T. Montfort. The action was taken in agreement with Section 4, Article C7 of the Constitution. The appointment will continue until a replacement can be elected by the membership in the next election. Nominees for the unexpired term of two years will be selected by the nominating committee and will be placed on the ballot to be mailed to voting members in February, 1957.

Mr. Edminster is drainage work project leader in the Eastern Soil and Water Management Section at Beltsville, Md. He is also assistant to the section head in program coordination and administration.

AAAS Annual Meeting

THE annual meeting of the American Association for the Advancement of Science, Section O (agriculture), will be held December 27-30 at the Hotel Martinique in New York City. The theme of the program is "Grasslands in Our National Life."

The program consists of three major parts. Papers on grassland research and practice will be presented on December 27 and 28. A symposium of invitation speakers will be held on December 29 and 30. The third portion of the program will be companion programs on grasslands by several individual societies.

An ASAE member, William C. Wheeler, will preside at the evening program on December 29. Applications of Engineering will be the topic covered in this session and the following ASAE members will present papers: William Chancellor, John J. Kolega, and Karl D. Butler.

The symposium held on December 29 and 30 is divided into four sessions and concerns (1) forage utilization and related animal nutrition problems; (2) forage production in temperate humid regions; (3) sciences in support of grassland research; (4) and grassland machinery and equipment, structures and irrigation systems. Eugene G. McKibben, ASAE member, will preside at the fourth session on grassland machinery and equipment, structures and irrigation systems, and Walter C. Hulburt, T. W. Edminster, J. B. Liljedahl, Edward A. Silver, Albert M. Best, and J. Dewey Long, all members of ASAE, will present papers.

EJC Report on Engineering Faculties

SINCE many engineering colleges are understaffed, steps are being taken to supplement salaries with research opportunity, consulting work and summer employment, according to a report, entitled Engineering Faculties by the Engineers Joint Council. According to the report, colleges encourage faculty to take summer employment in industry, often developing specific programs with cooperating companies. The report includes data on supply, demand and salary structure of faculties, according to academic grade and geographical location. Copies are available from Engineers Joint Council, 29 W. 39th St., New York 18, N. Y.

ASAE Meetings Calendar

December 9 to 12 — WINTER MEETING, Edgewater Beach Hotel, Chicago

December 27, 28—PACIFIC COAST SECTION, University of California, Davis

February 4-6 — SOUTHEAST SECTION, Birmingham, Ala.

April 5-6 — ROCKY MOUNTAIN SECTION, University of Wyoming, Laramie

June 23-26 — GOLDEN ANNIVERSARY ANNUAL MEETING, Michigan State University, East Lansing

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

ASEE Offers Research Award

THE Curtis W. McGraw Research Award, a new award in engineering education to recognize the research potential and accomplishment of young workers engaged in engineering research in a college or university, will be given in June, 1957, at the annual meeting of the American Society for Engineering Education, Cornell University, Ithaca, N. Y.

The award is sponsored by the McGraw-Hill Book Co. in memory of the late president of the publishing company, and will include a cash prize of $1000. It will be given annually beginning next June to a young man who has made original contribution in engineering research and who has demonstrated high potential for future leadership.

Another award, the Vincent Bendix Research Award, for contributions to the development of research activities and their management, was first given last June. The development of these two awards serves to emphasize the growing importance of basic research as a part of engineering education.

Nominations for 1957 candidates for the McGraw Research Award should be sent to James R. Cudworth, University of Alabama, University, Ala.

NSFE Spring Meeting

THE National Society of Professional Engineers will hold a meeting February 15-16, 1957, at the Hotel Francis Marion, Charleston, S. C.

MEMBERSHIP STATUS

"50 Hundred Members In Our 50th Year"

This slogan was originated by ASAE President Roy Bainer during the 49th Annual Meeting in June

August 1, 1956	4748
Sept. 1, 1956	4775
October 1, 1956	4803
November 1, 1956	4826
Applications being processed	243

Usually complete processing requires about two months after application has been received by ASAE Headquarters

Peanut Research Conference

A PEANUT Research Conference will be held in Atlanta, Ga., February 21-22, 1957, at the Biltmore Hotel. The conference is sponsored by the National Peanut Council in cooperation with ASAE, Farm Equipment Institute, Southern Farm Equipment Manufacturers, U.S. Department of Agriculture, and state agricultural experiment stations.

The theme is "Quality Through Research" and the objectives of the conference are: To provide for a better understanding and exchanging of knowledge from peanut breeder to the consumer; to define industry-wide peanut problems, and to coordinate and stimulate efforts towards solution of peanut problems.

The keynote address at the opening general session on Thursday, February 21, will give the purpose of the conference. Throughout the day reports will be made concerning factors that affect the quality as influenced by breeding and preharvest operations; harvesting, curing and processing; and sampling, grading, storing and shelling. The program is planned to cover peanut industry from plant breeding to manufacturing.

Friday morning, group meetings will be held to discuss the reports of the previous day and to arrive at general recommendations as to the most important problems confronting the peanut industry.

The concluding session will include reports by the chairmen of the morning groups and a summary talk giving the results of the conference and presenting the challenge for the job that lies ahead.

PSU Offers Service and Sales Course

THE agricultural engineering department of Pennsylvania State University offers a winter course in farm equipment service and sales. The program consists of four eight-week training sessions at the university and seven months placement training with a farm equipment dealer or manufacturer.

Classroom instruction will be given in farm structures, irrigation and drainage, electrical equipment, agricultural business methods, and in farm machinery. Any high school graduate interested in preparing for a career with the farm equipment industry may apply for admission to Director of Short Courses, College of Agriculture, Pennsylvania State University, University Park.

Southern Forest Tree Improvement Conference

THE Southern Forest Tree Improvement Conference will be held January 8-9, 1957, in the Continuing Education Building at the University of Georgia.

Recent accomplishments in forest tree improvement in the South will be discussed. Technical papers to be presented during the session will include topics on progress in seed orchard projects, racial variations, control of cone insects, innoculation techniques, flower and seed stimulation and other timely research problems. Speakers in the field of forest genetics will talk on subjects relating to their specialties. Exhibits and publications on various phases of forest research will be displayed and distributed.

Virgil Overholt (Fellow ASAE), who retired June 30 from the agricultural engineering department, Ohio State University, has been appointed special representative in agricultural drainage by The Hancock Brick & Tile Co., Findlay, Ohio.

He is one of the best known specialists in farm water problems in the middle west and recently received the Superior Service Award given by the U. S. Department of Agriculture.

A native of Hancock County, Ohio, Mr. Overholt has also lived in Defiance County, Ohio. He graduated from Ohio State University in 1915, and was that school's first extension specialist in agricultural engineering, a capacity in which he served for 41 years.

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Leonard F. Janssen has been appointed project engineer in the industrial and agricultural divisions of the Delavan Mfg. Co., West Des Moines, Iowa. His addition to the staff is part of a general program to enlarge the firm's engineering and research facilities.

Before joining Delavan, Mr. Janssen spent more than six years as an engineer with the Pioneer Seed Corn Co., and the John Deere Des Moines Tractor Works. He was graduated in 1949 from Iowa State College with a B.S. degree in agricultural engineering.

ASAE MEMBERS in the News


V. OVERHOLT


L. F. JANSSEN

Martin J. Pattyn, formerly zone manager, has been appointed as region manager of the midwest for the New Departure Div. of the General Motors Corp.

•

Price Hobgood, professor of agricultural engineering, A & M College of Texas, College Station, has assumed the duties previously carried on by the late P.T. Montfort. In addition to his teaching he will direct the research and other activities sponsored by the Texas Farm Electrification Committee.

Bruce A. Foster formerly associate editor of *Farm Implement News*, Chicago, Ill., has accepted a position as copywriter with Aubrey, Finlay, Marley and Hodgson, Inc., Chicago advertising agency.

•

Raymond J. Lynch has been assigned as engineering supervisor for the midwest region engineering projects of the New Departure Div., General Motors Corp., and will also handle specific divisional engineering activity. Formerly he was coordinator of the midwest region projects.

•

Rodney O. Martin, formerly extension agricultural engineer at the University of Maine, is now assistant professor of agricultural engineering, University of Pennsylvania. His responsibility in his new job is to set up a course in farm equipment sales and service.

•

Gene C. Shove, crop processing specialist and extension agricultural engineer at Iowa State College, is on a leave of absence for one year to study toward a Ph.D. degree. He will be working on distribution ducts for drying of grain, a project sponsored by Stran-Steel Corp.

•

Ted Willrich, extension agricultural engineer, Iowa State College, has received a public health service traineeship to do graduate work toward a Ph.D. degree in water sanitation. He has made many contributions in extension work in the field of soil and water conservation. He is on leave of absence until September, 1957.

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Denver O. Baxter, has joined the faculty of the agricultural engineering department at the University of Tennessee where he will do teaching and research. Formerly he was an extension agricultural engineer with the extension service at the University of Georgia.

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Maurice B. Cox has transferred his headquarters to the U. S. Akron Field Station, Akron, Ohio. He was formerly located at the Red Plains Conservation Experiment Station, Guthrie, Okla., as agricultural engineer for both that station and the Wheatland Conservation Experiment Station, Cherokee, Okla. His work at Akron will be concerned with the use of terraces for moisture conservation and crop production in the central high plains.

•

Orlean R. Moe has completed his training in sugar cane agriculture with the Hawaiian Sugar Planter's Association, and has accepted the position of assistant agricultural engineer in the industrial engineering department of the Hawaiian Commercial and Sugar Co., Ltd., Puunene, Hawaii. The company owns about 55,000 acres of land of which 25,000 acres are devoted to the growing of sugar cane.

•

J. B. Kelley, Life Member of ASAE and professor of agricultural engineering at the University of Kentucky, was presented a plaque by the Kentucky Rural Electrical Cooperative Corporation in Louisville for "outstanding and unselfish service to the rural electric cooperative program in Kentucky."

He has been active in the development of rural electrification in the state since 1935, when he made a survey of several counties to note the use of electricity in agriculture. He has assisted farmers in organizing cooperatives, has held special service schools for rural electric advisors, and has taught courses in rural electrification to college students. *(Continued on page 847)*

NECROLOGY

Frederick A. Wirt, Fellow and Past-President of ASAE, who retired in Sepember from J. I. Case Co. after 34 years service, died last month at his home in So. Carolina.

At the time of his retirement he was advertising manager of J. I. Case Co., having joined the company in 1922 as editor of the Case Eagle, a dealer magazine published by the organization. Prior to his employment with J. I. Case Co. he served on the agricultural engineering staff at Kansas State College in Manhattan; as sales promotion manager with John Deere Plow Co. at Kansas City, Mo.; as extension specialist in farm machinery and head of the agricultural engineering department at the University of Maryland; as sales promotion manager for the Emerson-Brantingham Implement Co. in Harrisburg, Pa., and as professor of agricultural engineering at the University of Arkansas.


F. A. WIRT

Mr. Wirt was born in Omaha, Nebraska, in 1891. He attended the University of Nebraska graduating in 1913 with a bachelor's degree in civil engineering, although he specialized in agricultural engineering.

He contributed much to the advancement and use of communication media in agriculture, and was active in the development of direct mail as a selling method. He was one of the first to advocate the use of slides for presenting information about products and farming practices, and was instrumental in promoting the use of motion pictures, product literature and public relations for advertising.

He joined ASAE in 1916 and served as its president in 1925-26. He became Life Fellow in 1949. He was active in the Farm Equipment Institute and was a charter member of the Soil Conservation Society of America. He was active in many phases of citizenship and was well known for his lectures and articles.

Earl G. Welch, agricultural extension engineer, University of Kentucky, died November 4 after a two-month's illness.

He was a native of Iowa and received a bachelor's degree in agricultural engineering at Iowa State College in 1944. After graduation he immediately joined the agricultural engineering teaching staff at the University of Georgia, doing extension work during the summer. In 1920 he was appointed extension agricultural engineer at the University of Kentucky where he was serving at the time of his death.


EARL G. WELCH

A member of ASAE since 1918, Mr. Welch received a citation from Secretary of Agriculture Ezra Taft Benson in June, 1956, for outstanding and superior service in the field of agriculture. The citation specifically referred to his "leadership in developing needed agricultural engineering practices for Kentucky, and in getting these practices accepted and applied by the farmers of the state."

In September, 1956, he received recognition at a Kentucky Agricultural Extension Service dinner for his long service to agricultural engineering and for the USDA Superior Service Award.

He was joint author of several circulars published by the extension division of the University of Kentucky. He was a member of the Baptist Church.

With the ASAE Sections

North Atlantic Section

Herbert N. Stapleton, agricultural engineer, Shelburne Farms, Shelburne, Vt., was elected chairman of the North Atlantic Section at the meeting held in Ithaca, August 30. Byron L. Bondurant, head, agricultural engineering department, University of Maine, was elected as vice-chairman, and Arthur G. Fox, agricultural engineer, New England Power Service Co., Clinton, Mass., was elected secretary-treasurer.

Connecticut Valley Section

The Connecticut Valley Section held a meeting in the Publick House, Sturbridge, Mass., October 10, 1956. Chairman Charles Chunglo presided.

Following various committee reports a general discussion was held on the need for students in agricultural engineering. Suggestions of ways to obtain new students were contributed.

The following officers were elected for the coming year: chairman, J. W. Zahradnik, University of Massachusetts; vice-chairman, R. L. Kinner, Western Massachusetts Electric Co., and secretary-treasurer, W. A. Bailey, USDA, University of Connecticut.

The speaker for the evening was Stuart Williamson from Douglas Fir Plywood Association, New York, N. Y. He talked on how, when and where to use different grades of plywood.

Michigan Section

A meeting of the Michigan Section was held at the agricultural engineering building, Michigan State University, October 13, 1956. Nearly 100 members and visitors were in attendance during the forenoon technical meeting, noon luncheon and afternoon football game between MSU and Indiana. Approximately 50 wives attended a forenoon coffee and social hour followed by films on selected subjects.

The technical meeting consisted of three papers on the general theme of atomic energy and radiation. The first paper on plant nutrient radio active tracers was presented by K. Lawton of the soil science department, Michigan State University. W. K. Dorn, Tracerlab Inc., Boston, Mass., presented the second paper, which was about radiological tracers, application and instrumentation. The third paper, on irradiation of farm products and the engineering involved, was presented by L. E. Brownell, fission products laboratory, University of Michigan. New developments in this field of radiation and radioactive tracers were brought to the attention of the group and discussed.

A. W. Farrall welcomed the group to the campus and discussed the plans for the Golden Anniversary Meeting to be held at Michigan State University, June, 1957. Merle L. Esmay, agricultural engineering dept., Michigan State University, presided. Robert Alpers, chairman of Michigan Section, discussed the objectives of ASAE and of the Michigan Section. He urged that each member stress increased membership during the Golden Anniversary Year.

Hawaii Section

A meeting of the Hawaii Section was held October 17 with 14 members and guests in attendance.

The following officers were elected for 1957: Chairman, Adam F. Scott, Ewa Plantation Co.; vice-chairman, Harry R. Cerney, California Packing Corp., and secretary-treasurer, Walter P. Burton, Experiment Station, Hawaii Sugar Planters Association. Arthur F. Wallace, Harold B. Chapson, and Donald M. Kinch were on the nominating committee.

A discussion followed concerning the aims and objectives of the Section for 1957. It was suggested that a meeting be held in which each of the members could give a brief summary of the problems he encounters in his work. A report was given on the present status of the "Hawaii Engineer's" magazine by John Cykler in which he stated that articles from ASAE members would be welcome.

Ohio Section

Rain emphasized the importance of a program largely devoted to corn drying, when the Ohio Section opened its fall meeting, Friday afternoon, October 26. A banquet that evening, a Saturday morning program and business meeting, and a homecoming football game Saturday afternoon, with a score generally satisfactory to Ohio alumni, rounded out the program.

More than 80 section members registered for the meeting and wives joined their husbands for the Friday evening banquet. Students raised the Friday afternoon attendance over the 100 mark.

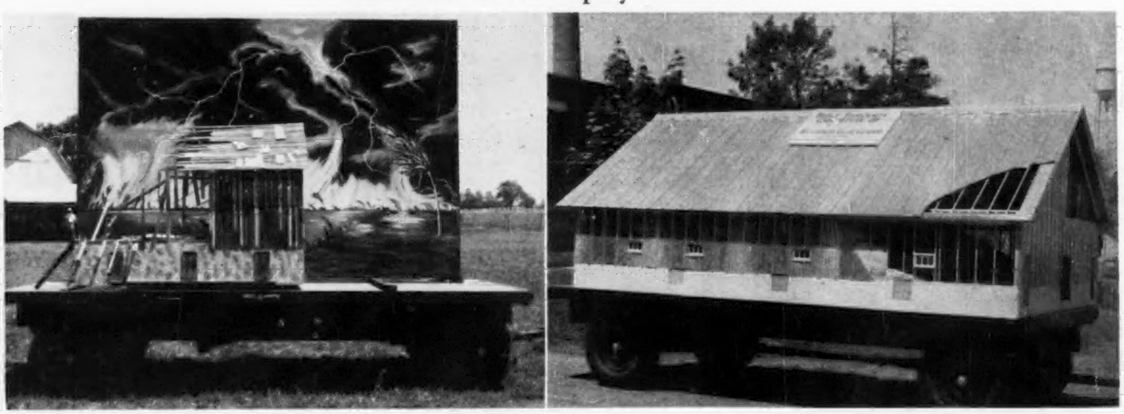
Contributors to the corn drying program were Wm. H. Johnson, Ohio Agricultural Experiment Station; Wm. V. Hukill, ARS, USDA; Nolan Mitchell, Aerovent Fan and Equipment, Inc.; Henry J. Barre, vice-president ASAE and consulting agricultural engineer; Earl D. Anderson, Stran-Steel Corp.; and John W. Sharp, agricultural economist, Ohio State University.

Another feature of the program was a panel on opportunities in agricultural engineering for engineering students. Panel members were E. S. July, Ohio Tractor and Implement Co.; R. R. Raney, New Idea Division, Avco Manufacturing Corp.; D. M. Byg, Ohio Extension Service; B. J. Lamp, Ohio State University, and Virgil Overholt, retired from Ohio State Extension Service.

A talk by G. W. McCuen, retired head of the agricultural engineering department of Ohio State University, on his trip last spring to Southern Europe, North Africa and the Near East, illustrated by a selection of colored slide pictures he had taken on the trip, was the feature of the evening program.

Robert C. Evans, vice-chairman, presided over the technical sessions. Truman Gains, chairman, was master of ceremonies at the banquet and conducted the business meeting. C. Edwin Smith, secretary-treasurer, read minutes of the previous meeting and reported the Section financially solvent. B. J. Lamp reported activities and plans of an agricultural engineering promotion committee including publication of a brochure for vocational guidance, development of a speakers' list, and gathering of information for speakers on agricultural engineering.

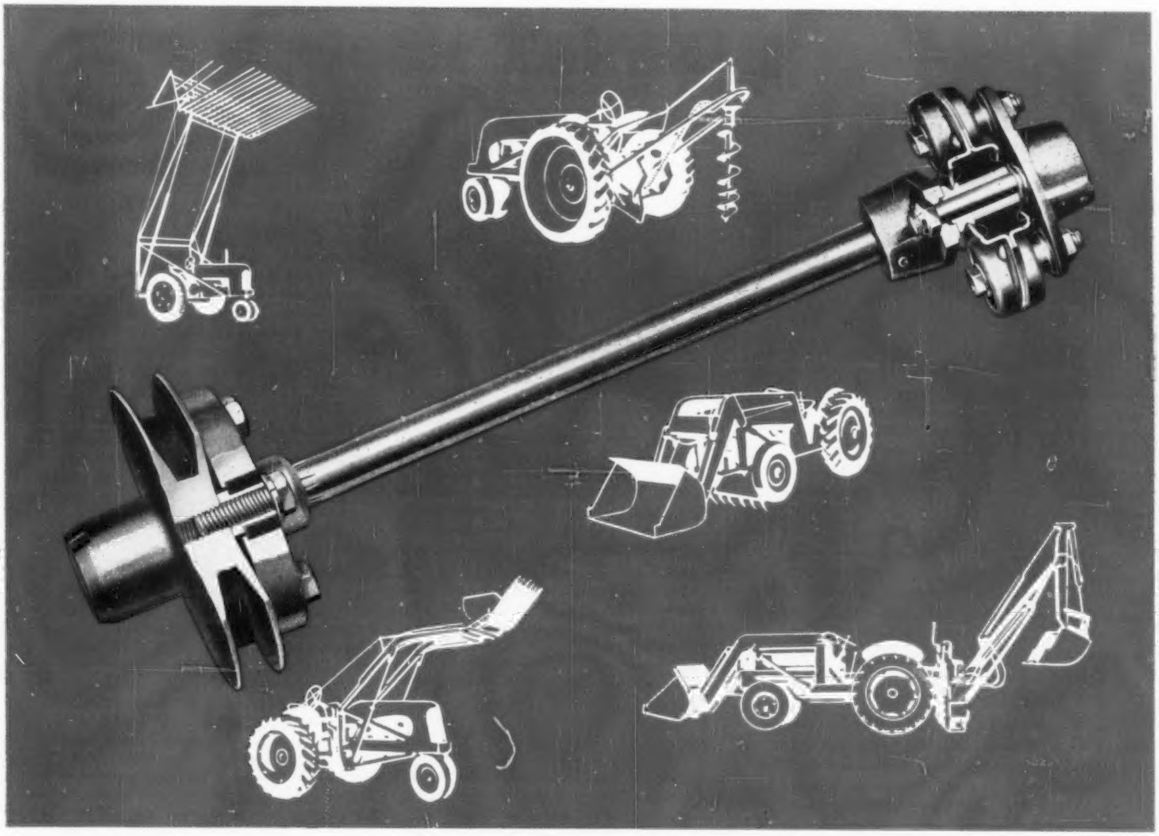
Farm Structure Display on Wheels



The department of agricultural engineering of Ontario Agricultural College, Guelph, Canada, devised an interesting method of displaying types of building plans that are available in the Canadian Farm Building Plan Service. All building models are constructed to exact scale and includes pole-frame cattle barn, pole-frame poultry house, hog house, machine shed, fruit and vegetable storage, milk house, and miscellaneous structures. Each model is mounted on tractor-drawn trailers. A complete program has been arranged, including a running commentary and was shown during the Annual Farm and Home Week in June before nearly 30,000 visitors. A model barn was burned down to show the hazards of fire and another building was shown demolished by hurricane forces *(left)*. Safety, economy, and work simplification were other features displayed during the program. Later it was shown to 4-H clubs and in September it played an important part in a seminar in farm buildings conducted by the college for members of the Ontario Retail Lumber Dealers

The secret behind the Morflex Driveshaft's amazing ability to . . .

end vibration and misalignment problems in PTO Pump Drives



Cut-away view illustrates Morflex neoprene biscuit principle applied at both ends of shaft.

Driveshaft vibration and misalignment of the pump frame support have always been twin bugaboos with tractor power-takeoff drives. They put excess strain on hydraulic pumps and quickly wear out pump bearings.

The Morflex Driveshaft solves this problem. Special resilient neoprene biscuits in the driveshaft couplings give unusual torsional flexibility; compensate for all conditions of shaft misalignment: angular, axial, and parallel. The special design of the neoprene biscuits absorbs vibration, provides uniform stress and deflection under all operating conditions.

Unaffected by dust, dirt, water or weather, Morflex Driveshafts are ideal for the roughest jobs. They require no lubrication or maintenance.

Compact Morflex Driveshafts fit limited space requirements; can be designed to fit specifications of mass-produced, tractor-mounted equipment.

If you have a PTO driveshaft problem, it will pay you to investigate Morflex Driveshafts. Phone, wire, or write us today for fast assistance and full details. MORSE CHAIN COMPANY, INDUSTRIAL SALES DIVISION, ITHACA, NEW YORK.

MORSE MORSE BW* BORG-WARNER POWER TRANSMISSION PRODUCTS

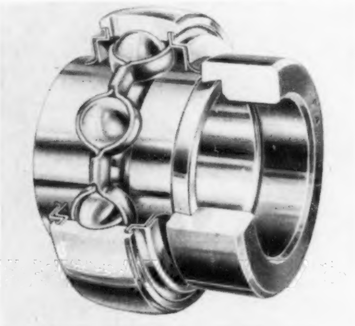
*Trademark

NEW PRODUCTS CATALOGS

Wide Inner Ring Bearing Adds Pliable Type Seal

The Fafnir Bearing Co., 37 Booth St., New Britain, Conn., has incorporated its "Plya-Seals" in its line of wide inner ring ball bearings. The new development is designed to seal out excessive amounts of contaminants when running at slow to moderate speeds, and still retain the bearing's supply of grease.

The seal consists of two dished steel plates, between which is sandwiched a synthetic, rubber-impregnated, fabric sealing

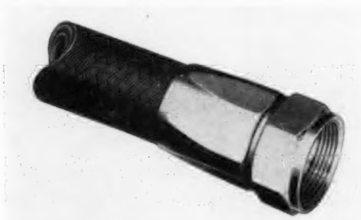


washer. Both steel plates are fixed securely in an outer ring groove, and the inner plate provides a rigid backing for the seal washer and a close-clearance baffle for retention of grease. The outer plate is slightly shorter to permit the seal washer to flare out in wiper fashion, providing a tight contact between the inner ring O.D. and the sealing washer.

The new bearing is dimensionally interchangeable with the mechani-seal type bearings, and is equipped with a self-locking collar. It is available either in the relubricatable or non-relubricatable type. They are also available, incorporated in Fafnir line of power transmission units.

Reusable Hose Ends

The Weatherhead Co., Fort Wayne Division, Fort Wayne, Ind., has announced a new line of reusable hose ends identified as model H-69. The new design is particularly suited for use where medium-high pressure, cotton-covered, single-wire braid



hose is required. Compact design permits close coupling to conserve space. Threads match SAE and JIC standards.

Sizes are as follows: Inverted male thread, $\frac{1}{4}$ to $\frac{3}{8}$ in; female swivel, $\frac{1}{4}$ to 2 in; rigid male pipe, $\frac{1}{8}$ to 2 in. Swivel nuts in the $\frac{1}{4}$, $\frac{5}{16}$ and $\frac{1}{2}$-in sizes will connect to either JIC 37 deg or SAE 45 deg fittings. In $\frac{3}{8}$-in size the $\frac{9}{16}$-18 thread will connect to the JIC 37 deg and the $\frac{5}{8}$-18 thread will connect to the SAE 45 deg fittings. Swivel-type end no. 8 is 14 pitch (AC811) thread.

Flexible Tool Bar Planter

Deere and Co., Moline, Ill., has announced its new No. 70 series flexi-planter for use in a wide range of applications in both narrow and wide-row crops.

The new planter consists of self-driven units which clamp on any $1\frac{1}{2}$ to $2\frac{1}{4}$-in square tool bar. These units will plant sugar beets, edible beans, soybeans, corn, maize, sorghum, and many types of vegetable seeds. Rows can be spaced as narrow as 13 in. The 13 planting rates range from 5 to 20 ft of forward travel for every revolution of the seed plate. Because the units are self-

contained and self-driven, they can be used on front-mounted cultivator frames as well as on rear tool bars. Special hopper equipment for use with monogerm or processed beet seed includes a smooth, stainless-steel tube to aid free fall. Seed falls only 12 in from hopper to furrow.

Each unit floats on a parallel linkage for uniform-depth planting on uneven ground, and is mounted so that 85 percent of the weight is carried on the drive wheel and the trash-cutting double-disk opener. Penetration and drive are further aided by adjustable spring down-pressure of as much as 80 lb.

Offers New Tractor Cab

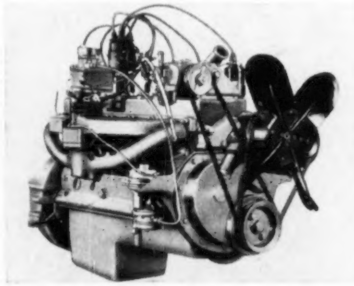
The Oliver Corp., Chicago, Ill., has introduced a new cab for its Super 99 and Super 99 GM tractors. Full stand-up height and panoramic visibility for both sitting and standing positions are featured. A sloping, full-width, full-height windshield is stand-

ard equipment, and a complete selection of side and rear enclosures is offered — demountable hinged side windows, glass-windowed rear doors or canvas rear curtains. The top is sheet steel covered with an insulation material to help absorb sound.

6-Cylinder Jeep Engine

The Industrial Engine Department of Willys Motors, Inc., Toledo, Ohio, has announced development of a new Jeep 6-cylinder engine for industrial use. The engine was designed specifically to produce high torque at low speeds.

Pistons are of aluminum alloy, each with a control band. This band is cast into



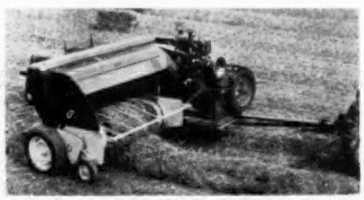
the piston around the skirt as protection against collapse of the piston skirt. It is reported that piston slap and high oil consumption are reduced by the control band. Each 4-ring piston is fitted with full hard chrome top compression ring and a full hard chrome steel rail oil ring.

Other features include new heavy-duty bearings, forged counter-weighted crankshaft, new manifolding, single-barrel carburetion, a compression ratio of 6.9 to 1, and 226-cu in displacement. The company reports full-load ratings of 143 lb-ft maximum continuous torque and 33 continuous hp at 1200 rpm. At 2600 rpm the maximum continuous torque is 132 lb-ft, and continuous horsepower is 65.

New Baler

New Holland Machine Co., New Holland, Pa., has announced a new family-size baler, called the Hayliner 68, which features a new principle in baler feeding. It reportedly measures the hay that goes into each bale slice forming bales of equal size and density.

Described as having "flow-action" feed, the hay runs through the baler with no sharp corners to turn. A spring-loaded tine feed does the measuring. The tines lower into the hay and push it into the bale chamber. The lifting action of the tines as they return for another charge spreads the hay through-



out the bale chamber. Emphasis has been placed on gentle handling of hay.

A new tension tie and precision action are said to give improved bale tying. Knotters are located close to the chamber to reduce twine slack, and new-type needles are designed to wrap the twine around the bale in such manner as to hold the hay tight until the knot is ready to be tied. Other features include a clutch on the pickup drive which helps to control flow of hay into the feeder and to guard against choking in extra-heavy windrows; a floating pickup; fewer moving parts, and a liberal use of anti-friction bearings. It is available in either PTO or engine-driven models.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Allard, Gordon Herbert—College graduate trainee, Caterpillar Tractor Co., Peoria, Ill. (Mail) 311 Morton St., Creve Coeur

Baldvinsson, Thorir — Chief architect Teiknistofa Landbunadarins, Bunadarbanki Islands, Reykjavik, Iceland

Bing, John H.—Product engineer, New Idea Division., Avco Mfg. Corp., Coldwater, Ohio

Biskis, Kestutis S.—Layoutman, International Harvester Co., Tractor Works (Mail) 1931 So. 49th Ave., Cicero, Ill.

Bridges, James Luther — Agronomist, Research Foundation of the State University of New York (Mail) American Embassy, USOM, Tel Aviv, Israel

Camp, Carl Rosser, Sr. — Partner, Haney-Camp Tractor Co., P.O. Box 115 Centre, Ala.

Camp, Walter T.—Sales manager, Bearings Co. of America, Division of Federal-Mogul-Bower Bearings, Inc., Detroit, Mich. (Mail) 501 Harrisburg Ave., Lancaster, Pa.

Cannon, Moody Dale — Assistant professor and assistant agricultural engineer, Agriculture experiment station, University of Arizona, Tucson, Ariz. (Mail) 3102 E. 2nd St.

Capper, Dennis Bowen—Director of Trymech Ltd. and chief design engineer for Denings of Chard (Mail) Old Rose Cottage, Elton, Nr Ludlow, Salop, England

Carpenter, Billy Joe—Design engineer, East Moline Works, International Harvester Co. (Mail) 1436½ Grand Ave., Davenport, Iowa

Chant, Lonnie Ray—Plant engineer, United Concrete Pipe Corp., P.O. Box 10283 Industrial Station, Dallas, Texas

Corretjer, Carmelo A. Gonzalez—Engineer, Agricultural Extension Service, PO Box 607 Rio Piedras, Puerto Rico

Coulter, Charles Pitts—Assistant sales manager, Cole Mfg. Co., Charlotte, N. C. (Mail) 1519 Audubon Rd.

Courtenay, John Clement—Trainee, Westinghouse Electric Corp. (Mail) 446 North Bradford St., Gainesville, Georgia

Cox, Charles W. — Farm Service Engineer, Central Illinois Light Co., Peoria, Ill. (Mail) 316 S. Jefferson St.

Cox, Richard Graves, Jr.—Sales representative, Cleveland Graphite Bronze Co., Suite 1001, 332 So. Michigan Ave., Chicago, Ill.

Crowder, John Preston, Jr. — Senior engineer, Virginia-Carolina Chemical Corp., PO Box 1136, Richmond, Va.

Decker, John F. — District extension irrigationist, Nebraska Agricultural Extension Service, PO Box 186, Sargent, Nebr.

Devakul, Debriddhi—Chief of engineering, Rice Dept., Ministry of Agriculture, Thailand

Dias, Galloluwege Robert William—Director, Machinery Research Section, Ceylon Research Station, Mahailluppalama, Ceylon

Douglas, Earl Henderson—Engineer, Axelson Mfg. Co., Division of U.S. Industries, Los Angeles, Calif. (Mail) 6013 W 76th St.

Fabian, Zdenek — Design engineer, Oliver Corp., South Bend, Ind. (Mail) 2621 Cypress Way

Fife, LaVon S. — Manager, economic research, farm implement division, International Harvester Co. (Mail) 823 No. LaGrange Rd., La Grange Pk, Ill.

Forepaugh, Vance B. — Supervisor, farm market, Gulf Oil Corp., 1515 Locust St., Philadelphia 2, Pa.

Fridley, Robert Bruce — Junior specialist, Agricultural Experiment Station, University of Calif., Davis, Calf.

Gill, William E.—Extension farm machinery specialist, Ohio State University, Columbus, Ohio

Haise, Howard Ross—Technical staff specialist in charge, western soil and water management section (SWCRB, ARS) USDA, Colorado A and M College, Fort Collins, Colo.

Hillstrom, Hugo F. — Ventilation engineer, Farm Engineering Sales, Inc., Savage, Minn. (Mail) Cokato, Minn.

Holteick, Chester Boyd — Project engineer, Hawaii Sugar Planters Assoc. Experiment Station, 1527 Keeaumoku St., Honolulu, Territory, Hawaii

Howell, Henry E.—Owner, Henry Howell Drainage Contractor, 510 E. Higham St., St. Johns, Mich.

Jensen, James Keith — Project engineer, John Deere Waterloo Tractor Works, Waterloo, Iowa

Kesler, Herman—811 Piedmont Ave., N. E., Atlanta, Ga.

Kimble, William Harley—Chief product design engineer, Brillion Iron Works, Inc., 200 Park Ave., Brillion, Wis.

(Continued on page 836)

Applicants for Membership

(Continued from page 834)

Lacayo, Guerrero Armando—Assistant head agricultural engineering, Servicio Tecnico Agricola De Nicaragua, Managua, Nicaragua, C.A. (Mail) 363 West Shaw Hall, East Lansing, Mich.

Lamont, Robert D.—District sales representative, Cleveland Graphite Bronze Co., 332 So. Michigan Ave., Chicago 4, Ill.

LeGros, Lawrence—Manager, experimental fabrication, Tractor and Implement Division Ford Motor Co., 2500 E. Maple Rd., Birmingham, Mich.

Leslie, Howard O. — Sales engineer, Chain Belt Co., Milwaukee, Wis. (Mail) 2825 27th Ave., Rock Island, Ill.

Long, Melvin E. — Experimental engineer, John Deere Dubuque Tractor Works, Dubuque, Iowa

Low, Robert M.—Sales representative, New Holland Machine Co., New Holland, Pa. (Mail) 6B University Heights, Burlington, Vt.

Macdonald, John Thomas—Research assistant in agricultural engineering, University of Connecticut (Mail) Pomfret Center, Conn.

Martens, Maurice J.—Agricultural engineer, John Deere Spreader Works, East Moline, Ill. (Mail) 2144 10th St. Place, East Moline, Ill.

Meyer, Vernis H. — Junior engineer, John Deere Des Moines Works (Mail) Granger, Iowa

Morrison, Keith A. — Field representative, Michigan Farm Equipment Assoc., 515 Murray Bldg., Grand Rapids, Mich.

Olson, E. I.—Chief field engineer, Durkee-Atwood Co., 215 7th St. N.E. Minneapolis 13, Minn.

Pasley, Robert M. — Agricultural engineer, (SCS), USDA (Mail) PO Box 259, Marion Kans.

Peters, James Douglas — Trainee, Westinghouse Standard Control Division (Mail) 702 First Ave., S. W., Moultrie, Ga.

Peters, Robert John — Salesman, Reynolds Metals Co., 1500 Fisher Bldg., Detroit, Mich.

Platte, Gene A. — Partner, Platte Brothers Farm Trenching, RR 2, Portland, Mich.

Platte, Marvin J. — Partner, Platte Brothers Farm Trenching, RR 2, Portland, Mich.

Polvi, Robert Leo — Graduate student in Agricultural engineering, Oregon State College, Corvallis, Ore. (Mail) 335 No. 10th St.

Potter, John Delwyn—Agricultural and commercial engineer, Gulf Power Co., 34 East Garden St., Pensacola, Fla.

Reece, Wendell Dale — Engineer trainee, John Deere Des Moines Works, Des Moines, Iowa (Mail) 3011 27th St.

Roach, Donald H.—Sales engineer, Bower Roller Bearing Division, Detroit, Mich. (Mail) 2921 24th Ave., Moline, Ill.

Said, Nasir—Graduate student in agricultural engineering, Oregon State College, Corvallis, Ore. (Mail) 114 No. 15th St.

Saunders, Peter—Designer, W. S. Atkins & Partners, Consulting Engineers, 158 Victoria St. London, S.W. 1, England (Mail) 24 Upper Rd., Foster Clark Estate, Maidstone, Kent, England

Snavely, Charles Albert — Executive secretary, Illinois Retail Farm Equipment Assn., 3500 North Adams St. (PO Box 1146), Peoria, Ill.

Springston, Rex Bailey — Rural representative, Virginia Electric Power Co., Roanoke Rapids, N. C.

Tharp, Russell Warren—Trainee, Caterpillar Tractor Co., Peoria, Ill. (Mail) 917 Pammel Ct, Ames, Iowa

Vanderhoof, Sumner F. — Field representative, Olin Mathieson Chemical Corp., St. Louis, Mo. (Mail) 1310 St. John, Garden City, Kansas

Weaver, Harold R. — Owner, Harold R. Weaver Trenching Service, 3667 36th St. S.E. Grand Rapids 8, Mich.

Wegman, James—Sales engineer, Industrial Pump Corp., PO Box 5116, Tampa, Fla. (Mail) 4405 West Anita Blvd., Tampa, Fla.

Wilkes, Raymond Steele — Trainee, John Deere Spreader Works (Mail) 4546 13th Ave., Moline, Ill.

Yerkey, Berma Blaine—Engineer specialist, (SCS), USDA, Keyser, West Va. (Mail) PO Box 329, Keyser, West Va.

Yuenger, Robert L. — Design and development engineer, Starline, Inc., 300 W. Front St., Harvard, Ill.

Transfer of Membership Grade

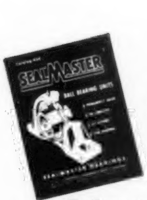
Burrowbridge, Donald R.—Agricultural sales engineer, Public Service Co. of Northern Illinois, 314 So. State St. Belvidere, Ill. (Associate Member to Member)

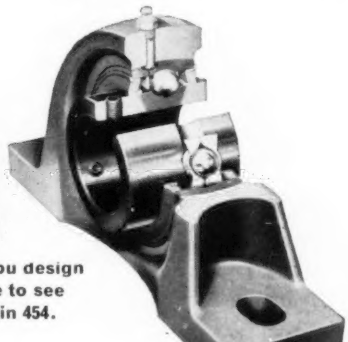
Foster, Bruce Allen — Copywriter, Aubrey, Finlay, Marley and Hodgson, Inc. (Mail) 211 Shabbona Dr., Park Forest, Ill. (Associate Member to Member)

(Continued on page 838)

HERE'S HOW

SEALMASTER HELPS YOU TO SERVE HIM BETTER





Before you design be sure to see Bulletin 454.

Throughout the farm machinery industry, engineers are busy designing new and better machines, not only to make the U. S. farmer's job easier but more efficient and profitable. Replacement sales bear out the fact that the farmer wants more than a rolling, clanking machine to get him by. He is well aware of the cost of maintenance and work stoppages and has become increasingly quality conscious. He looks beyond the trim design and brightly painted exterior into the "guts" of the machinery. The bearings are an important checkpoint in his search for quality. SEALMASTER Bearings have become synonymous with quality in farm machinery. Patented SEALMASTER features like Zone Hardening, Floating Ball Retainer, Locking Pin & Perimeter Dimple and Labyrinth Seal assure maximum performance and smooth power transmission. Find out today what they mean to you in customer satisfaction and repeat sales.

SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO., 67 RIDGEWAY AVENUE, AURORA, ILLINOIS

NEW BOOKS

The Future of Arid Lands, by Gilbert F. White. Cloth, 6x9 inches, ix+453 pages. Illustrated and indexed. Publication No. 43 of the American Association for the Advancement of Science, 1515 Massachusetts Ave., N. W., Washington 5, D. C. $6.75.

This volume contains the papers and recommendations from the International Arid Lands Meetings. Scientists from 17 countries and from as many disciplines met to assess the state of man's struggle to make productive and stable use of the world's arid lands.

The book records a range of thinking without attempting to reconcile differences of view or to fill obvious gaps. The individual papers and the group recommendations may be considered guideposts to scientific development in at least three ways. They mark a promising method of collaboration across both national and disciplinary boundaries. They point to specific areas of research where more activity is needed. They suggest methods of thinking about the future that may play a significant role in shaping that future.

The contents include sections on: Variability and predictability of water supply; better use of present resources; prospects for additional water sources, and better adaptation of plants and animals to arid conditions.

Applicants for Membership

(Continued from page 836)

Harbage, Robert P. — Product engineer, New Idea Division Avco Mfg. Co., Coldwater, Ohio (Mail) 400 Harrison, Greenville. (Associate Member to Member)

Leme, Hugo de Almeida — Professor and head, machinery section, Luiz Queiroz College of Agriculture, University of San Paulo, Piracicaba Est., S. Paulo, Brazil, South America (Affiliate to Member)

Luscombe, James A. — Agricultural engineer-in-charge, (ARS, AERB), USDA (Mail Box 107, Clemson, S. C. (Associate Member to Member)

Rumley, E. S. — Manager, product planning and programming office, Tractor and Implement Division, Ford Motor Co. (Mail) 678 Covington Rd., Birmingham, Mich. (Associate Member to Member)

Shove, Gene Clere — Graduate assistant in agricultural engineering, Iowa State College, Ames, Iowa (Associate Member to Member)

Van Syoc, Wendell M. — Engineer, tractor development, John Deere Waterloo Tractor Works (Mail) 1906 Iowa St., Cedar Falls, Ia. (Associate Member to Member)

Westerberg, Kenneth W. — President-manager, Farm Engineering Sales, Inc., Savage, Minn. (Affiliate to Member)

Williamson, Leslie Howe—Agricultural engineer (SCS) USDA (Mail) 926 E. Central Ave., Hemet, Calif. (Affiliate to Member)

Willrich, Ted L.—Assistant professor and extension agricultural engineer, Iowa State College (Mail) 1911 Burnett St., Ames, Iowa (Associate Member to Member)

Witt, Robert H. — Product design engineer, International Harvester Co. (Mail) 644 Lakeside Dr., Hinsdale, Ill. (Associate Member to Member)

Zakiyah, Adib — Teacher, Agricultural Secondary School of Damascus, Ministry of Agriculture, Hader St., Hame, Syria (Associate Member to Member)

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The complete auger, for gathering cut grain back of the sickle bar, is furnished by Link-Belt for this harvester-thresher.

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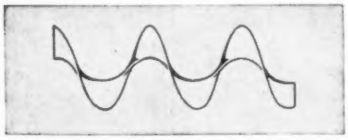

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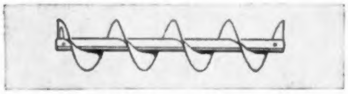
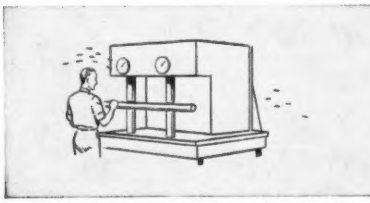


SIMPLICITY OF CONSTRUCTION and sturdy design of Link-Belt augers provide dependable, efficient operation on your machine. One basic assembly — no other moving parts to break down.



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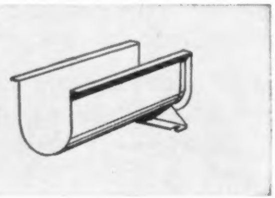

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PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated. "Agricultural Engineer" as used in these listings is not intended to imply any specific level of proficiency or registration as a professional engineer. Items published herein are summaries of mimeographed listings carried in the Personnel Service, copies of which will be furnished on request. To be listed in this Bulletin, request form for Personnel Service listing.

POSITIONS OPEN — JUNE — O-181-632, O-181-653. JULY — O-183-634, O-180-636, O-198-637, O-215-638, O-216-639, AUGUST — O-234-641, O-217-643, O-239-644, O-240-645, O-244-647, O-262-648. SEPTEMBER — O-271-650, O-305-651, O-307-652, O-292-653, O-314-654. OCTOBER — O-330-655, O-316-656. NOVEMBER — O-252-657, O-363-658, O-365-660, O-365-661, O-365-662, O-382-663.

POSITIONS WANTED—JULY—W-190-23. AUGUST — W-283-26. SEPTEMBER — W-284-27, W-308-29, W-359-30. OCTOBER—W-315-31, W-323-33, W-328-34, W-332-35. NOVEMBER—W-255-36, W-379-37.

NEW POSITIONS OPEN

AGRICULTURAL ENGINEERS (2) for extension work, one with rank of professor, one associate or assistant professor, for planning and execution of extension program based on needs of commodity groups in an eastern state. Age 26-36. BS deg in agricultural engineering or equivalent. MS deg preferred for higher ratings. Several years of responsible engineering experience necessary for higher ratings. Able to cooperate and interested in helping farmers and consumers through the application of engineering principles to agricultural production and marketing problems. Good opportunity for advancement. Salary $5889-$9826, according to qualifications and rank, 11-months basis. O-374-664

AGRICULTURAL ENGINEER, assistant or associate professor rank, for research in cranberry mechanization in an eastern agricultural experiment station. Age 24-30. MS deg in agricultural engineering or equivalent, or BS deg and 2 yr in machine development work. Able to cooperate with associates and farm groups. Salary $5889-8684, according to qualifications and rank. O-374-665

AGRICULTURAL ENGINEERS, for sales, service or sales management in steel farm buildings and crop conditioning equipment with nationally known organization. Excellent market, growing business. Sales experience preferred. Excellent opportunity to advance in sales management. Salary open. O-384-666

GRADUATE ENGINEER for design and development work on hay and forage machines. Qualifications must include 5 years or more experience in the implement field or advanced schooling such as MS deg in engineering. Plant located in central Midwest city of 35,000. Salary open, depending upon experience and ability. Excellent opportunity for advancement. O-385-667

AGRICULTURAL ENGINEER or related training to develop irrigation sales program with established farm equipment distributor located in Michigan and Indiana. Age 28-40, good family man, able and willing to travel over two state area. Several years sales experience required, pilot's license important. Salary commensurate with experience. O-388-668

ENGINEER, preferably with hydraulic experience, wanted for general work on large western government irrigation project. Work to consist of office and field engineering, directing hydrographic work, and canal and dam operation. Opportunity for administrative work and direction of maintenance on canal system. Housing available. Salary $4,480 per year, plus approximately $300 overtime per year for graduates, $5,335 per year plus $300 for engineer with 6 mo experience. O-389-669

AGRICULTURAL ENGINEERS (2 or more) for design and development of structural and mechanical equipment, including original design, field test, production design, and follow through on pilot run with established manufacturer in Midwest. Age-25-40. BS deg in agricultural or mechanical engineering, or equivalent practical experience. Farm background preferred. Neat appearance and ability to work with production and sales groups. Desire to live in small community. Good opportunity for advancement. Salary open. O-394-670

AGRICULTURAL ENGINEER to assist manager of agricultural engineering with a name brand vegetable canner in the Upper Midwest. Work will include assisting with design and development on tillage, fertilizing, planting and harvesting equipment; and with maintenance, improvement, management and operation of fleets of field machines. Age about 24-28. BS degree or higher in agricultural or mechanical engineering. Practical experience in design and development, servicing or fleet operations desirable. Must be able to work with people. Excellent opportunity for well-qualified man, interested in application of engineering principles to agricultural production operations. Salary $450 monthly to start. O-393-671

AGRICULTURAL or MECHANICAL ENGINEER for research in handling, transportation, and storage of perishable agricultural commodities, with federal agency. Location in East. Age, under 35. BS deg or higher in agricultural or mechanical engineering. Experience in refrigeration and instrumentation desirable. Interest in research. Qualifications for federal civil service. Opportunities and benefits usual for civil service. Salary $6115 to $7035. O-396-672

DESIGN ENGINEERS, to handle creative design work on agricultural and industrial machines. BS or MS deg in agricultural or mechanical engineering required. Positions require creative ability and a pleasant personality. O-401-673

AGRICULTURAL ENGINEER for new position as research and new product development manager with established manufacturer of farm materials handling equipment in Upper Midwest. Responsible for conceiving, designing, developing, and acquiring new products for established and new markets. Will work closely with engineering department. Age 30-45. Degree in engineering. Farm background. Practical engineering and sales experience. Inquiring mind. Ability in speaking and writing. Cooperative. Successful administrative background and proven record of accomplishment. Salary open. O-402-674

(Continued on page 842)

You get *something extra* when you call in Cleveland Graphite Bronze

Cleveland Graphite Bronze has become the leading maker of sleeve bearings and bushings because of the "extras" we give our customers.

One extra we give our customers is ***outstanding engineering:*** fundamental research at the Clevite Research Center; original thinking at the design stage; searching thoroughness in testing and development. To follow through, we have a fast, able team of field engineers, working on specialized problems in our customers' plants.

With this concentration on engineering, we have introduced almost all the real improvements in our industry in the past 35 years, and have put them to work for the leading manufacturers in half a dozen different fields.

C. G. B. customers are getting the best advice, and getting it first. Are you missing out on it?

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The Cleveland Graphite Bronze Co.

Sleeve bearings and bushings and
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NEW BULLETINS

Septic Tanks for Dwellings, by Earl G. Welch and James B. Kelley. College of Agriculture and Home Economics, Agricultural Extension Service, University of Kentucky (Lexington) Circular 431 (revised).

This 23-page circular discusses plans for a sanitary sewage disposal system on a farm. The contents include sections on disposal without running water; disposal with running water where a septic tank is needed; operation of septic tank disposal system; design features of septic tanks; constructing a concrete tank; concrete block septic tank; the disposal field; disposal of sewage in poorly drained and tight soils, and care of a septic tank.

Mechanical Potato Harvesting (A summary of work in Maine), by H. D. Bartlett and D. H. Huntington, Maine Agricultural Experiment Station, University of Maine, (Orono). Bulletin 549 (July, 1956).

This 23-page bulletin covers the work on potato harvester development for Maine. The mechanical principles of harvesters, the field performance of the machines with different features, methods of handling the potatoes from the harvester into storage, and economic considerations of mechanical harvesting are described. Cost analysis and harvesting performance of mechanical harvesters for the 1955 season are reported.

Copies of the bulletin are available by writing to the Maine Agricultural Experiment Station, Orono.

Patterns and Classes of Rainfall at East Lansing, Michigan, and Their Effect Upon Surface Runoff, by James L. Smith and George A. Crabb, Jr. Reprinted from the Quarterly Bulletin of the Michigan Agricultural Experiment Station, East Lansing, Vol. 39, No. 1 (August, 1956).

This paper presents some of the relationships found to exist between certain patterns and classes of rainfall and the occurrence of surface runoff from watersheds at the Michigan Hydrologic Research Station where the tests were made. Precipitations totaling 0.25 inch or more were analyzed in this study. For the purpose of the study, rainfall classes were defined as the range of intensity within which the major portion of precipitation occurred during a given storm. Patterns were defined as the section of storm, with relation to time, at which the highest intensities are concentrated.

Better Construction with Threaded Nails, by E. George Stern. Virginia Polytechnic Institute Wood Research Laboratory, Blacksburg. Bulletin No. 25 (September, 1956).

This 16-page bulletin discusses the merits, types, and the uses of threaded nails. It is illustrated with pictures, and includes a specification data chart for threaded nails. The bulletin reports that the improvements made and economies achieved as a result of the use of properly threaded nails are important to architects, builders, and prospective home owners. On a nationwide basis the savings involved are tremendous when considering that over a million homes are being built during a year, and lumber can be saved by increasing the spacing between studs by using threaded nails.

Personnel Service Bulletin

(Continued from page 840)

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for design, development, research or writing in soil and water field with public service, consultant, or farming operation in South or East. Willing to travel. Interested in field work. Widower. Age 26. No disability. Available now. BS deg in agricultural engineering 1954, University of Tennessee. Experience 9 mo in farm machinery parts depot. SCS 2 mo before entry in military service, as assistant to work unit conservationist. Commissioned service in Army Corps of Engineers 2 yr with assignments as accountable post engineer, supply and spare parts officer, assistant post engineer responsible for operations, heavy equipment, safety program, suggestion evaluation, assistant fire marshall, supervision of major repair and construction projects, depot land management plan, and landscape plan. Salary $5,000. W-377-38

GRADUATE AGRICULTURAL ENGINEER, with 15 yr experience in operating, maintaining and some construction on all sizes of government irrigation projects. Last five years supervised all phases of operation and maintenance at large western government dams and canals system. Age 39 years, married. Prefer western United States. Salary $8,000 per year. W-390-39

AGRICULTURAL ENGINEER for design, development or research in power and machinery or rural electrification with industry or public service, anywhere in the United States. Occasional travel. Married. Age 27. No disability. Available January 1. BS deg in agricultural engineering, June 1952, University of Idaho. Active commissioned service in USAF, 2 yr. Farming on 80-acre irrigated farm for 2 yr. Salary open. W-366-40

AGRICULTURAL ENGINEER for extension, teaching, research, or writing, in rural electric or product processing field, with industry or public service, in Midwest or West. Limited travel preferred. Married. Age 31. Corrected vision. Slight hearing defect. Available on reasonable notice. BS deg in agricultural engineering, 1951, University of Nebraska. Farm background. Part time employment while attending the University. With public power districts 5½ yr as electrical consultant. Enlisted service in Infantry 18 mo. Salary $6,000 to $6,500. W-391-41

ASAE Members in the News

(Continued from page 827)

H. B. Puckett, formerly assigned to the USDA tobacco-curing research project at Oxford, N. C., is now engaged in research work to develop chore labor-saving equipment for the farm, with emphasis on automatic feed handling and preparation. This work is in cooperation with the agricultural engineering department, Illinois Agricultural Experiment Station.

•

John K. Buttfield has been transferred from the Chicago office of the Oliver Corp. to serve as production manager of Oliver Australasia Pty., Ltd., a new subsidiary of Oliver Corp., in Sydney, NSW, Australia.

•

Edward A. Lim is returning to his home in the Philippines after doing postgraduate work in electrical engineering in the United States. He has accepted a position as sales engineer with the International Harvester Co. in Manila.

•

Mansel M. Mayeux has joined the staff of Louisiana State University at Baton Rouge as associate agricultural engineer in the agricultural engineering department. Formerly he was chief inspector for the Anhydrous Ammonia Commission of the Louisiana Department of Agriculture and Immigration.

•

Thomas H. Garner has been appointed to the position of research instructor of agricultural engineering at North Carolina State College. He will deal in cotton mechanization problems and teach classes in farm machinery. His research work will be directed to determining the influence of seed planter elements on the environments surrounding the cotton seed as they affect germination.

He received a B.S. and M.S. degree in agricultural engineering from North Carolina State College. While working on his M.S. degree, he was the recipient of an assistantship established by the Scott-Viner Co. of Columbus, Ohio, for work on peanut mechanization.

•

Leo O. Stoeber, formerly sales engineer with Delco Products Division, General Motors Corp., is now employed as sales manager by MaGirl Foundry and Furnace Co. in Bloomington, Ill.

•

W. E. Anderson has left Phoenix, Arizona, where he was employed as engineering specialist with the Soil Conservation Service, to become associated with the Colorado River Storage Project, U.S. Department of Agriculture Field Party, in Salt Lake City, Utah.

•

Conner Stephens is now with the farm power division at the Agricultural and Technical Institute in Alfred, N. Y. He was formerly an instructor in agricultural engineering at the Long Island Agricultural and Technical Institute in Farmingdale, N. Y.

•

C. T. Sturdivant formerly with the Servicio Agricola Inter-Americano, La Paz, Bolivia, is now working with the International Cooperation Association of Salvador, USOM, San Salvador, El Salvador.

•

Joseph R. Jones has been appointed assistant agricultural engineer (cotton ginning), Agricultural Extension Service, A & M College of Texas, College Station and has resigned his position with Southern Harvester Co., Columbus, Ga.

Index to Advertisers

Professional Directory

RATES: 80 cents per line per issue; 40 cents per line to ASAE members. Minimum charge, five-line basis. Uniform style setup. Copy must be received by first of month of publication.

Agricultural Engineers Yearbook

Supply of the 1956 edition of AGRICULTURAL ENGINEERS YEARBOOK has been exhausted. Copies of the 1955 edition are still available at $3.00 per copy postpaid.

Send order with remittance to
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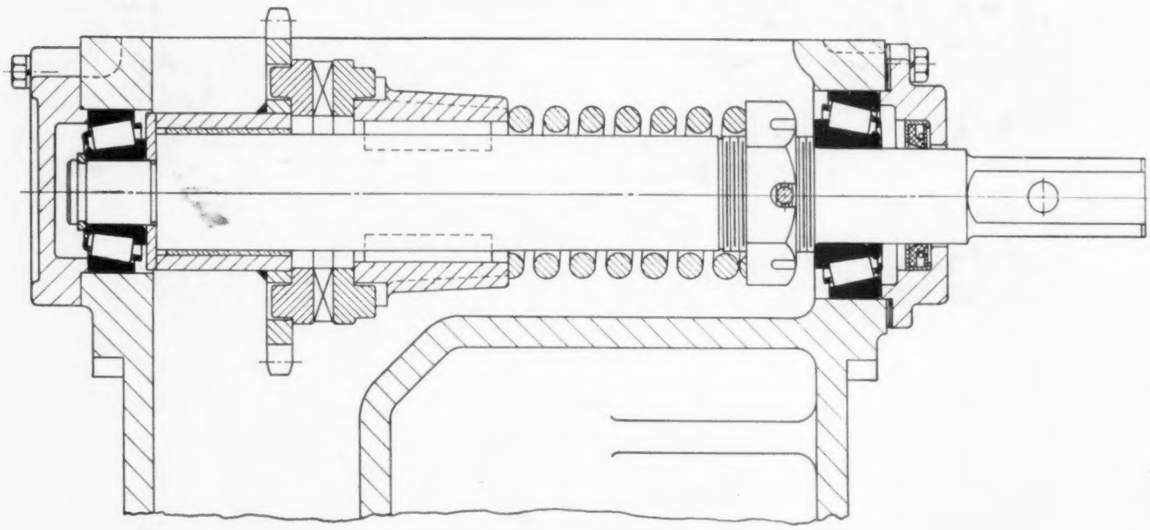
How Oliver Engineers get Longer Life, Minimum Maintenance in Mower Transmission



ONE way Oliver Engineers design longer life into their mower transmission is by mounting the clutch shaft on Timken® tapered roller bearings (see drawing above).

Timken bearings normally last the life of the machine in which they're used. Because their design, by geometrical law, gives them true rolling motion. Because they're manufactured with microscopic accuracy to live up to their design. And because they're made of Timken fine alloy steel made in our own mills. We're America's only bearing manufacturer who can control quality every step of the way.

More and more agricultural engineers are designing Timken bearings into their implements to lick three of their biggest problems: 1) combination loads, 2) dirt and 3) ease of operation.

Timken bearings take both radial and thrust loads in any combination. It's the taper.

They keep shafts concentric with housings. This makes closures more effective. Keeps dirt out of bearings. Keeps lubricant in. Cuts maintenance for farmers.

And Timken bearings reduce friction to a minimum so that implements operate more smoothly and easily.

For ideas on how to design advantages of Timken bearings into the projects on your drawing boards, write today for your free copy of "Tapered Roller Bearing Practice in Current Farm Machinery Applications". The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

The farmer's assurance of better design

TIMKEN Tapered Roller BEARING EQUIPPED

NOT JUST A BALL NOT JUST A ROLLER THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION